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O.P. JAGGI

HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA

DAWN OF INDIAN SCIENCE

VEDIC AND UPANISHADIC PERIOD

VOLUME TWO

ATMA RAM & SONS DELHI-6

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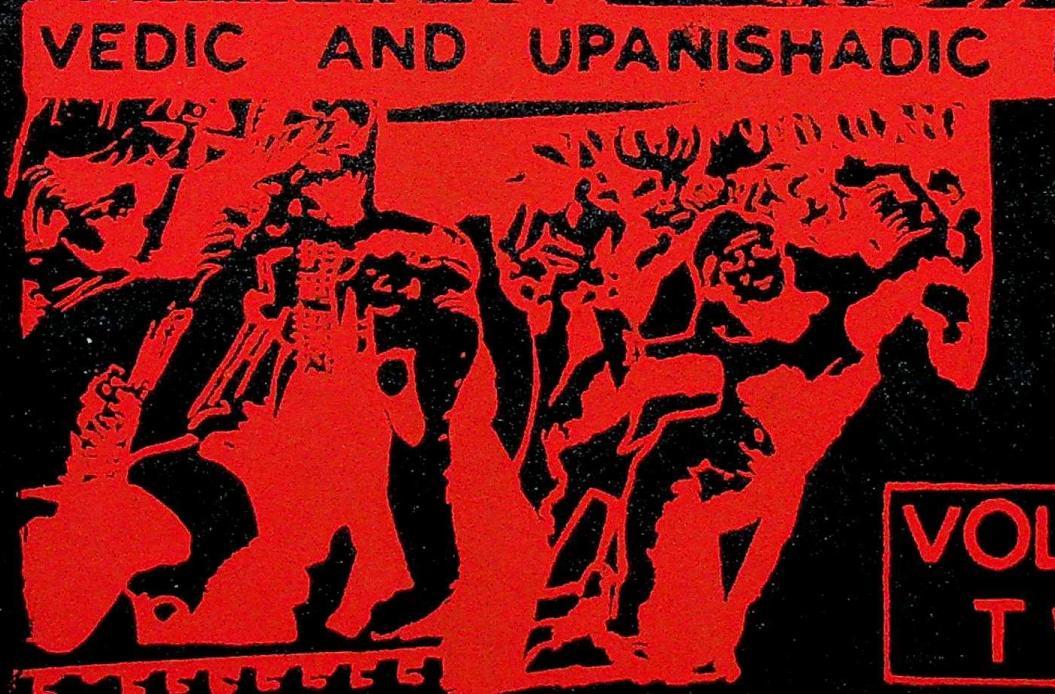

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Vol. I

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HISTORY OF SCIENCE
AND TECHNOLOGY IN INDIA

VOL. TWO

DAWN OF INDIAN SCIENCE

(VEDIC AND UPANISHADIC PERIOD)

by

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FOREWORD
by

Prof. D. S. KOTHARI

Chairman
University Grants Commission
New Delhi

1969

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इदं नम ऋषिभ्यः पूर्वजेभ्यः पूर्वेभ्यः पथिकृद्भ्यः

To the seers, our ancestors, the first path-makers.

(*Rigveda X. 14. 25*)

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Foreword

by

Prof. D. S. KOTHARI

Chairman, UNIVERSITY GRANTS COMMISSION

NEW DELHI-1

THE HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA by Dr. O.P. Jaggi is a welcome and valuable addition to the relatively meagre literature on the subject. I believe the book would be of interest to a wide circle of readers.

There is now an increasing and deepening interest in the history of Indian science and technical inventions, extending over a very long period of time. To some extent this has been stimulated by Professor J. Needham's monumental work on Chinese science. (This work contains several interesting and highly suggestive references to India's contributions.) For a proper understanding of the social and political history of a country, a knowledge of the history of science and technology is of the utmost importance. Again, there has always been an active interaction and cross-fertilization between scientific and technical developments in different parts of the world: the flow of ideas and discoveries cuts across all barriers. Much has been written about the history of Western ancient and medieval science, and yet in a true sense the history of Western science will remain *incomplete* without an adequate knowledge of the growth of science in the East, and India specially.

I hope Dr. Jaggi's present work will contribute significantly towards a more sustained study and research so that at not too distant a future, we have a much fuller, documented and integrated account of the major events and trends in the history of science and technology in India.

April 26, 1969.

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Preface

Just as now we believe in the vast and expanding extents of the universe, in the existence of a variety of elements and their physical and chemical properties, and in the efficacy of modern therapeutic measures in different diseases, in a similar way, in ancient times, Indians of the Vedic civilization believed in their gods who, they thought, created, ran and maintained the universe and propitiating whom by means of different incantations and rituals was sure to bring good luck and well-being.

If now, to us, some of their beliefs appear puerile and primitive magic, it only shows that alongwith the ubiquitous biological evolution, there has occurred scientific and cultural evolution as well, passing as it did, through different stages—from primitive to different grades of development.

Looking back on this scientific and cultural evolution of the Indian society, can help us in more purposeful planning for the future. Moreover, it can tell us as to why we still have certain peculiar beliefs, traditions, even myths and superstitions which have hindered our progress towards a more scientific attitude of mind.

There are, no doubt, many hurdles in the way, which, to an extent, impose limitations on the present work: the fundamental one is that of the material on which we base our study. To begin from the beginning, we notice that the picture of the Vedic society that we draw is based entirely on the sources that are of a religious character, namely, the Vedic literature which includes the Samhitās, Brāhmanas, Upanishads etc. Though they reveal a lot, yet it is possible that they reveal only one aspect of the whole. To a large extent this limitation applies to the study of other ancient civilizations as well *viz.*, of Mesopotamia, Egypt and ancient Greece. But that can only give us a consolation; it does not solve the problem.

Another limitation, and this peculiar only to the ancient Indian civilization, is that of chronology: when did a particular event occur or an idea flourish, is not known with certainty. In the present state of our knowledge, I feel, it is better to admit of this gap in our knowledge rather than be emphatic about the dates.

Vedic people certainly did not think in terms of our present-day water-tight disciplines of cosmogony, cosmology, physical and chemical reactions etc.—the way the subject has been presented in this book. This style had to be adopted and the material fitted in under these titles because we are used to this approach and it facilitates our grasp of the subject. Moreover, it makes it easy to compare the concepts of one civilization with the other.

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I am grateful to the Director General, Archaeological Survey of India, for the photograph that is included in this volume. To the publishers M/s Atma Ram & Sons and the printers M/s Raisina Printery, I am obliged for their help and co-operation in bringing out this volume.

August, 1969

O. P. J.

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Abbreviations

AB	Aitareya Brāhmana
Apsl	Āpastamba Sūlba Sutra
AV	Atharvaveda
Bsl	Baudhāyana Sūlba Sutra
Ch. U.	Chhāndogya Upanishad
Enc. Brit.	Encyclopaedia Britannica
KB	Kaushitaki Brāhmana
Ksl	Kātyāyana Sūlba Sutra
MB	Mahābhārata
PDS	Padārtha Dharma Samgraha
RV	Rigveda
SB	Śatapatha Brāhmana
TB	Taittiriya Brāhmana
TS	Taittiriya Samhitā
VS	Vājasyāni Samhitā

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1

Introduction

ARYANS

Some of the Indo-European tribes left their original homeland situated in the territories of Central Asia about 1950 B.C. and settled in the region of the Iranian plateaus. After living there for nearly four hundred years, differences—essentially perhaps, of religious nature—developed amongst them, so as to divide them in two broad groups: the Daiva-worshippers and the Asura-worshippers. Around 1500 B.C., majority of the Daiva-worshipping tribes left or were made to leave the Iranian plateaus and they entered into the north-western border region of the Indian subcontinent.

ARYAN SETTLEMENT IN INDIA

These Indo-Aryan tribes, in short, the Aryans spread in every direction in the Indian subcontinent; in the north towards Kashmir, the Himālayas and the Gangetic doāb, in the east towards Kosala, Videha, Magadha and Anga and in the south towards Narmadā and Vidarbha. The three broad subdivisions of the Indian subcontinent that were under their control were called as Brahmavarta or Aryāvarta, Madhyadeśa and Dakshinapatha. The focal point of the Aryan activity at this time was, however, around the region of Kurukshetra (now a part of the Haryanā state, in northern India).

These are the people whose culture, mode of thinking and achievements—all these from the point of view of the origin of the spirit of scientific enquiry—we will discuss in this volume.

Our knowledge of these Aryans is based upon evidence of

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the Vedic literature which consists of the four collections or Samhitās namely Rigveda, Sāmaveda, Yajurveda and Atharvaveda and the various Brāhmanas, Āranyakas, Upanishads and the Sutras.

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2

Vedic Literature

The following survey has only a limited objective—to name and describe the characteristics of the different texts that form part of the Vedic literature, so as to get familiar with them in the very beginning and to have no difficulty in placing them properly when they are referred to again in the later chapters.

The Vedas are called Śruti (from śru, to hear), since they were handed down orally from teacher to disciple. They were committed to writing centuries after their composition, but that has not made the slightest change either in the composition or even in the pronunciation of their contents. They were and are considered too sacred to be tempered with in any way.

The four Samhitās (from sam, together; and hita, put, literally meaning, put together) are the collections of hymns and prayers which were recited at the time of religious sacrifices.

The Brāhmanas, on the other hand, contain the rules and regulations for the sacrifice and reveal the meaning of the hymns.

A further development of the Brāhmanas and partly included in them, are the Āranyakas or forest treatises, intended for those who had retired into the forest and were consequently unable to perform the sacrifices in the usual way. They prescribe symbolic worship and meditation, in place of the ritual sacrifices. Herein, worship is lifted from the physical to the mental level.

Each Samhitā had its own Brāhmanas, Āranyakas and the Upanishads. In many cases the last portion of the Āranyaka is the Upanishad. As an example, the Taittiriya Samhitā has Taittiriya Brāhmana, at the end of which is the Taittiriya Āranyaka followed by Taittiriya Upanishad.

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SAMHITĀS

Rigveda Samhitā: On linguistic grounds, out of the four, Rigveda Samhitā appears to be oldest. Much of its contents, in their present form, seem to belong to a period around 1000 B.C. Some of the hymns in it, however, look to be older—may be as old as 1500 B.C. or even more.

Different parts of the Rigveda seem to have been composed at different times, so that it represents a sort of whole literature accumulated over the centuries. Majority of the hymns are the product of the intellectual activity when the Aryans had found their way into India and accepted it as 'home'. The others seem to have been composed—or at least existed in their minds—even before they entered India. That is why a few of the hymns remind us of the meteorological and astronomical conditions that prevailed thousands of years ago, somewhere outside India. And that is also the reason why we see in the Rigveda thoughts, beliefs and practices which we can only associate with primitive grades of society, rubbing shoulders with the sophisticated and advanced metaphysical speculations.

Rigveda is divided into ten mandālas (books). These mandālas consist of suktas (hymns) and there are more than a thousand suktas in the Rigveda. Furthermore each sukta has in it, on an average, about ten chhāndas (verses). In the references about Rigveda, the first number denotes the mandāla, the second sukta and third the chhānda.

Of the ten books of the Rigveda the second and those following it are the so-called 'Family Books'. The contain groups of 'potent' hymns, which it seems, were composed by the ancient Aryan priests, seers and holy singers to propitiate gods at the time of different sacrifices. The basic ideas behind these hymns are said to have been revealed to them by the gods. These hymns later became the family properties and were guarded zealously, so much so that their owners occasionally marked them by letting their names appear somewhere in the verses.

Thus we see, that Rigveda is not an historical record by any

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chance, but is mainly a collection of hymns of a number of priestly families, recited or chanted by them on appropriate occasions. And yet, they reveal a lot about the Vedic times and society, as we shall see later.

Sāmaveda and Yajurveda Samhitās: These are full of rituals for the different sacrifices. In fact, they seem to have been compiled strictly from the point of view of their use at the sacrifices. They are sort of text books for conducting sacrifices.

Yajurveda has two branches: Krishna Yajurveda and Śukla Yajurveda. They are also called as Taittiriya Samhitā and Vājasneya Samhitā.

Atharvaveda Samhitā: This is very interesting and informative. It informs us of the popular beliefs and superstitions of the masses in their day-to-day life. It also reveals a lot about the practice of the healing art during those days.

BRĀHMANAS

Next to the Samhitās, in time, are the Brāhmanas. These texts are full of speculations about the rituals of the sacrifices. There were many Brāhmanas attached to each Veda in earlier times, but only a few of them are available now.

Of the Rigveda, the Brāhmanas are Aitareya and Kaushitaki (also called Śānkhāyana), of Sāmaveda Jaiminiya and Tāndya, of Yajurveda (Vājasneya) Śatapātha and of Atharvaveda the Gopatha.

ĀRANYAKAS

Texts of the different Āranyakas were composed by seers who lived, meditated and performed sacrifices in the surroundings of the forests, as they had renounced the social life of the world.

Meditation, rather than performance of the sacrifices is the essence in all the Āranyakas. They lay stress on the efficacy of the inner or mental sacrifice as distinguished from the outer or formal sacrifice. In this way, the Āranyakas helped to bridge the gulf between the previous period of the Brāhmanas and the period

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of the Upanishads that followed.

Aitreya and Kaushitaki are the Āranyakas of the Rigveda, as is the first Āranyaka-like section of Chhāndogya Upanishad of the Sāmaveda and Taittiriya of the Taittiriya Samhitā.

UPANISHADS

The word Upanishad, derived from the root 'up-ni-sad' meaning 'to sit down near some one', initially referred to the pupil sitting down near his teacher, while the latter imparted his secret doctrine to the former. The word Upanishad is also said to be derived from the root 'sad', to which are added two prefixes: 'upa' and 'ni'. The prefix 'upa' denotes nearness and 'ni' totality. The root 'sad' means to loosen, to attain, and to annihilate. Thus the etymological meaning of the word is the knowledge which when received from a competent teacher loosens totally the bondage of the world and enables the pupil to realize Ātman or Self. Later on, the word Upanishad itself came to be applied to the text in which such knowledge or doctrines were contained. Upanishads number more than one hundred.

The Upanishadic literature collectively is also called Vedanta, 'the end of the Veda'—not because it came at the end of the Vedic period or was taught at the end of Vedic instruction, but because it exhibited the final aim of the Vedas.

Some of the oldest Upanishads are partly included in the Brāhmanas and the Āranyakas. There are others which came later but are pre-Buddhistic, and others still which have come down to us either independently or in larger collections. Those in the last category have very little connection with the Vedas and some of them are more akin to the Purānas and the Tāntras.

Names of some of the important Upanishad are:—Aitareya, Kaushitaki, Taittiriya, Mahānārāyana, Brihadāranyaka, Chhāndogya, Mundaka, Maitrāyani and Māndukya.

Origin of the Upanishads: There are some hymns even in the Rigveda[1] which express doubt about the efficacy of the priestly

1. RV X 129.

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cult and the then current beliefs in gods. Some of the hymns of the Atharvaveda and some portions of the Yajurveda also throw the same hint. Āranyakas are clearly a manifestation of a deviation from excessive ritualism. These anti-ritualistic trends soon gathered momentum. They were directed against the Brāhmana caste, mainly by the Kshatriyas.

During later Vedic and early Upanishadic period, there existed kings and warriors of the Kshatriya caste who besides being very proficient in their own profession, delved also in literary and intellectual activities and had attained such high eminence in this respect that they always had a thing or two to teach even to the Brāhmanas. Not only the kings and warriors but even some of the women and other non-Brāhmanas, took part in the intellectual life of the times. These non-priestly circles who were opposed to Brāhmanaic ritualism formed the nucleus of the free-thinkers and gathered around them such people as came in their fold. They kept aloof from the sacrificial ceremonies and followed the 'way of knowledge' (Jnāna mārga). It was through them that the philosophic thinking gradually replaced many of the rituals of the sacrifices. Here it is interesting to notice that such rivalries between the Brāhmanas and the non-Brāhmanas existed even in ancient times, as they do now.

The dialogues of the Upanishads indicate that due to the ponderings of these knowledge-enthusiasts, around eighth century B.C., a shift of emphasis occurred from the outer universe and tangible spheres of the body to the inner and the intangible. A process of withdrawal from the normally known world took place. Eminent gods like Agni, Mitra and Brihaspati did not receive their due through prayer and sacrifice. Instead of propitiating these symbolic guardians and models of the natural and social order, these men were directing their minds and attentions inwards, towards Self (ātman) awareness by means of self-analysis, breath-control and other stern disciplines of Yoga.

Such highly philosophical ideas contained in the different Upanishads are as much relevant to our times as they were when they were framed. In 1650 A.D., fifty Upanishads were translated

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into Persian under the patronage of Prince Darā, son of Śahājahan, the emperor of Delhi. From Persian, they were translated into Latin in 1801-1802 A.D. Schopenhauer, the noted German philosopher, studied this Latin translation and in later years said: 'In the whole world there is no study so beneficial and so elevating as that of the Upanishads. It has been the solace of my life, it will be the solace of my death.'

SUTRAS

Sutra meaning a 'thread', denotes a special style of the literature, which is made up of short sentences, running through a topic like a thread. A Sutra has thus come to mean, a short rule in as few a words as possible—an aphorism.

Both by their form and objective Sutras form a class by themselves. The system of oral instruction which formed the basis of education in those days, most probably necessitated this peculiar fashion of summarizing the entire exposition so as to help memorize it easily.

To the uninitiated, the Sutras look obscure and incoherent. This however, is natural because to be very explicit was not the objective of the Sutra composers. It is only the brevity that mattered; the clarity came through the teacher (guru).

Most of the Vedangas are composed in Sutra style. These Vedāngas are divided into six categories, namely, Shiksha (phonetics), Kalpa (ritual), Vyakarāna (grammar), Nirukta (etymology), Chhāndas (metrics) and Jyotisha (astronomy). These six Vedāngas help in proper understanding, recitation and sacrificial use of the Vedic hymns and that is why they are called the Vedāngas, 'the members of the Vedas'.

Majority of the Sutras were composed in the pre-Buddhistic period. Some of them do belong to later periods also.

Even though composed in the post-Vedic times yet what they deal in belongs clearly to the Vedic period and hence form part of the Vedic literature.

To us the Kalpa-sutras—which are also the oldest Sutras—are

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of interest. They are divided into two branches, namely, Śrauta-sutras and Grihya-sutras. Śrauta-sutras contain in them the Śulba-sutras, which are the manuals for the construction of a variety of sacrificial altars in different geometrical shapes. They reveal much of the knowledge and principles of geometry which the altar-making involved. Period of the composition of some of the principal Śrauta-sutras (*viz.*, those of Āpastamba, Baudhāyana, Kātyāyana, etc.) has been fixed to be between 800-400 B.C.

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3

Vedic Religion, Culture and Society

RELIGION AND PHILOSOPHY

Natural phenomena as gods: Rigvedic people, being essentially agricultural cum-pastoral, lived in small village communities. They spent most of their time in the open and so were generally speaking, more exposed to nature and the natural phenomena. They were deeply affected by the apparently mysterious working of the awe-inspiring forces of nature. The shining stars which follow a fixed and regular course across the sky, to them, were the devas (the shining ones), the gods. So were also the lightning, thunder, rain and fire. Dependence of the human welfare on the mercy of these mysterious forces, naturally led to the need to propitiate and worship them. This, we fully witness in the hymns of the Rigveda.

While attempting to live in harmony with the natural forces, the Aryans created a variety of myths about them. A myth is born when a natural event is interpreted as an action of a personified being, resembling a human being. The myth-creative fancy of the Rigvedic poets and seers went so far that a natural phenomena ultimately appears not as an unintelligible happening but an intended action of the forces of good and evil—of gods and demons. Rigvedic hymns beautifully reveal—as no other literary monument of the world does—the actual processes and stages of creation of a variety of religious myths, many of which still prevail amongst us. The hymns, in fact, hide little and a particular natural phenomena is clearly discernible behind the myth.

Propitiation of that phenomenon—god, in a variety of ways for the welfare of man in general, or for a particular object, forms

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a major part of the Rigvedic religion. Humanized gods of the Rigveda share some common weaknesses of man and seem to be just as susceptible to flattery and gifts. A full meal is certain to win favour of the gods—as of the human beings. Thank offerings are fairly common. A feeling of dependence is evident and surrender of one's possessions coupled with prayers and oblations is a common feature. And yet it is all done with a definite hope and expectation of rewards.

As the gods lived in the heavens above and the mortal beings on the earth, the fire (Agni) with its towering flames and ever-rising smoke became an intermediary messenger and as a bearer of oblational offerings from men to gods.

In time, a host of natural phenomena led to creation of a host of gods representing them. This multiplicity of gods, however, did not satisfy the Rigvedic sages. One god was, therefore, identified with another and gods were invoked in pairs or collectively in groups of three or even more. This gradually took the form of a sort of classification of gods with an over-lord, the Creator, the Supreme Brahma over them all—in the same way as the people had seen happening in their own society wherein there were the masses, the tribal chiefs and the powerful monarch. The Rigvedic religious philosophy thus passes and progresses through different stages—polytheism, monotheism and monoism.

Atharvavedic religion, on the other hand, is more popular and less refined. It is of the masses. It is full of primitive magic formulae which were used in the day-to-day life of the people. Some sparks of a high level philosophy—akin to the Rigvedic—is also witnessed here and there. Some scholars believe that the religion in the Atharvaveda is a mixture of the beliefs of the Aryan and the non-Aryan people and it came into existence as the Aryan overtook the subcontinent. The Aryans, they say, came across people who believed in magic and worshipped snakes, stones, trees etc. In the process of interchange of ideas and ideals, the Aryans absorbed into themselves these people as well as their ideas and what we find in the Atharvaveda is the result of such a sequence.

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THE CASTE SYSTEM

Admittedly, there is hardly a country where classes or orders of society or grades of social distinction of one form or another do not exist or have not existed even from time immemorial. Yet in India it has been a totally different process. The elaborate institution known as the caste system among the Hindus, is perhaps, without a parallel in the world. Here a common origin, name, tutelary deity, occupation, religious and social ceremonies and social status of a particular caste, distinguishes it from any other.

Such a caste system, as we know it today, passed and developed through different stages, from one age to another. Let us have a look and see how it originated in the Vedic Age.

Origin: We can trace transition from the casteless, though classified, society of the Rigveda to the elaborate caste system of the Yajurveda as follows:

In the increasing complications of life, resulting from gradual migration and spread of the Vedic Aryans from the north-western border regions to the Punjab and towards the east, west and south of the Indian subcontinent, the necessity of carrying on ceaseless battles and fights with the non-Aryans, called for an efficient organizer of battles and also of a permanent warring class, well-versed in the techniques of the battles. Thus emerged the powerful warring monarch, the tribal chiefs of different ranks and the warring class, the armed forces—the Kshatriyas.

They took upon themselves the task of conquering, ruling and maintaining law and order so that the other people could devote their time and energies, unhindered by battles, to their peaceful pursuits of agriculture, trade and different crafts. Those who pursued such trades and crafts constituted the Vaiśyas.

Furthermore, among the Aryans, in the beginning, everybody, from a householder to a monarch, could himself offer all sorts of sacrifices to the gods for himself and for his dependents, ample time being available for it. With the increasing load of work on the monarch, the tribal chiefs and the warring classes, in the military and administrative spheres of the ever-increasing realm, it

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became difficult for them to perform the religious sacrifices themselves. These sacrifices had, however, become all the more essential because of the struggles of life and the need to propitiate gods. The job of performing such ceremonies was thus ultimately handed over to those who knew them well and could be depended upon for their proper performance. Thus grew the priestly Brāhmanical class.

The conquered coloured people, the 'dasyus and the dasas', who worked at menial jobs for the Aryan conquerors, became the Śudra class.

Some idea of the social standing of these four classes can be had from a hymn of the Rigveda which mentions that the Brāhmanas, Kshatriyas, Vaiśyas and Śudras were created from the head, the breast or arms, the thighs and the feet of the Creator, Purusha[2].

The above four categories or classes in the Rigvedic times were not rigid. They were, on the contrary, more or less fluid so that a person of one class could easily be counted in the other, provided his professional capabilities permitted.

During the later Samhitās Period: In this period, the four classes of the Rigvedic period turned into the four rigid castes.

Gradually professions of the Brāhmanas and the Kshatriyas and the guilds of the workers such as of the smiths, leather-workers, carpenters, chariot-makers etc., tended to become rigid and later more or less hereditary. Secondly, the tradition that one could marry only within the clan (gotra) and not outside it, made the clans and the castes more fixed in their structure.

During this period, we also witness the hard-hitting social and religious injunctions placed on the Śudras by the higher castes, particularly the Brāhmanas. From now onwards, Śudra caste was at a disadvantage in every sphere of life. The doctrine of untouchability however, had not yet appeared.

Interestingly, while the Brāhmanas and the Kshatriyas had undoubted precedence over the other two castes, there was not

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2. RV X 90.

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the same unanimity in respect of the relative position of the Brāhmanas and the Kshatriyas.

FAMILY LIFE

During the Rigvedic period, head of the family was the father and in his absence, the eldest son. The sons and the daughters married generally of their own accord and at a mature age after puberty. There is no clear evidence to indicate that the consent of the parents was really essential. Polygamy was allowed. Chief aim of marriage was to have off-springs and the male issues were most welcome as they were the means to propagate the family line. Abundance of sons in the family was considered as a sign of good luck and their absence, of a bad luck. That is why prayers were offered to have the sons. No desire was however, expressed for a female issue. There is little evidence of the prevalence of the custom of 'Sati' (widow-burning) in the Rigvedic times.

DIET AND DRESS

Milk and its products formed a substantial part of the daily diet. Grain (yava) was parched and then ground into flour on a quern. This mixed with milk or butter and made in the form of cakes, was an article of daily diet. Vegetables and fruits were taken in large quantities. Eating of meat was not forbidden. It is said that horse flesh and perhaps even beef was eaten but only on the occasion of special ceremonial sacrifices. Soma juice, an essential constituent of certain sacrifices, was also taken. Surā, another beverage, was more popular and more intoxicating also. It was probably distilled from grain. Honey was liberally used.

Dress consisted generally of only two garments. Ornaments were part of the dress of both the sexes. People kept their hair properly oiled and combed.

Music, both vocal and instrumental, was highly appreciated.

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POLITICAL AND ADMINISTRATIVE SET-UP

The country occupied by the Vedic Aryans, was divided into numerous smaller tribal units governed by the tribal chiefs. A collection of such units formed the territory of a monarch or a king, who ruled over all his subjects.

Two assemblies called Sabhā and Samiti, consisting of prominent members of the kingdom, formed as essential feature of the government and the king took their advice concerning matters of the state. The royal authority was also materially curbed by the power and prestige of the purohit, the Brāhamana-priest. The priest accompanied the king to the battle-field also and prayed for success. Familiar instances of Vaśishtha and Viśvamitra are noteworthy in this regard.

Protection of the subject people was the sacred duty of the king. In return, he expected and received loyal obedience and tributes from his subjects. The king provided justice with the help of legal advisers, among whom Brāhmana-priest was included. Theft, burglary, robbery, cheating, particularly at gambling and lifting of cattles, were the commonly recorded crimes; the last being the commonest. Death sentence was not in vogue for any crime.

Land was probably owned by the people. A village made up of a large or small number of houses, mostly belonging to several branches of a single family, formed the basic unit of economy. It was practically self-contained and had for defensive purposes a fortified enclosure also. Towns with wooden walls and ditches all around them, were also known.

Rigveda gives us some idea of the mode of warfare in those days. The king and his chiefs fought from chariots and the army fought on foot. Martial music and banners were prominently displayed. The principal offensive weapon of war was the bow and the arrow. Points of the arrows were made of metal or horn and were frequently rubbed over with a poison. Other weapons were the lances, spears, axes, swords and sling-shots. A soldier was equipped with leather guards to protect the hands and arms

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from friction against the bow string. He also wore a coat-of-mail and helmet as defensive weapons—use of which is said to be one of the factors that led Aryans to victory. Horse-riding was well-known.

The king employed in his service spies (spāsha) to secure for him essential information about the affairs of his realm. He also had messengers (dutas) who communicated between different parts of the state and also between different states.

EDUCATION

The frog-hymn in the Rigveda[3] provides us a glimpse of the mode of imparting education during this period. It compares students in a class with a group of frogs croaking together. This is an appropriate simile of the chorus of voices heard when a teacher recited the Veda, verse by verse, and the students repeated after him. Evidently, then, the entire education was imparted orally. This does not however, imply that writing was unknown to the Rigvedic people.

During the period of later Samhitās, among the subjects studied by a student were arithmetic, grammar, prosody etc. There was however, no system of state education. The Brāhmana teachers taught the students of the three higher castes in their own (teacher's) homes, providing them both boarding and lodging. In return, the students served the teacher and gave him fees also.

Besides literary instruction, physical and moral care of the students was also considered essential.

MEDICAL PRACTICE

Atharvaveda, in a way, can be said to be a sort of compendium of the practice of the 'healing art' of those days. This we will take up elaborately in a later section of this book.

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3. RV Vii 103.

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AGRICULTURE AND CATTLE

Cutting furrows in the field with a wooden plough drawn by the bulls, sowing the seeds in these furrows, irrigating the fields, cutting corn with the sickle, laying bundles of corn on the threshing floor and then threshing, sifting and winnowing, are some of the operations of agriculture which are clearly described. The grain they produced and called 'yava', may be barley.

The Rigvedic people were primarily pastoral and naturally cows and bullocks were their most valued possessions. A cow returning from the pasture-land in the evening and licking her calf was one of the most pleasing sights, and lowing of the milch-cows, the most musical sound, to the Rigvedic Aryans. That a dark coloured cow gave a shining white milk was a perpetual source of wonder to them! They marked ears of their cattle to denote ownership. Bulls and oxen were regularly used for ploughing and drawing carts.

During the time of the later Samhitās, cow-dung was used as manure and its value was fully appreciated. Taittiriya Samhitā and other texts indicate that yava (barley) sown in winter was harvested in summer, rice sown in the rains ripened in autumn and the beans and sesamum planted at the time of the summer-rains ripened in winter. Wheat was known and is distinguished from rice and barley.

Plant pests that destroyed the seeds as well as the tender shoots of the plants were a source of frustration to the farmer. To prevent these and other similar misfortunes, the farmers made use of the charms, both at the time of sowing the seed and harvesting the corn. Spells in the Atharvaveda to avert drought or the excess of rains, show that the farmer during those days suffered the same mishaps as his counterpart does now.

TRADE AND COMMERCE

Inside the country, the commodities were exchanged on the principle of barter. Cow had come to be regarded as a unit of

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value. Nishka, originally a gold ornament, had perhaps also come to be used as currency.

Whether any sea-borne trade existed or not, in Rigvedic times, cannot be said with certainty. It did, however, flourish during the period of the later Samhitās.

OCCUPATIONS

Chariot-making was an honoured profession. Metal-workers smelted ores in the furnaces. They occasionally used wings of the birds to fan the fire. House-hold utensils were made of metal, pottery and even of wood. Tanning of the hides was well-known and leather was put to many uses. Ox hide was used to make the bow-strings, to fasten parts of the chariots and to make reins and lash of the whip. Mat-making and basketry and weaving and sewing of cloth was commonly done by women in their homes. There were dancers and barbers also.

Hunting as a sport and as a profession, was common. Nets and pit-falls were utilized for hunting, along with the bow and arrows.

During later Samhitā periods, there existed, besides the above occupations, the jewellers, washermen, cooks, foot-men for the chariots etc. More of this we will see later in the section on Technology.

BUILDINGS

As we know already, Vedic people lived in the villages. It is, however, difficult to determine the exact sense in the Rigveda of the word 'pur', which in later times certainly meant a town. A 'pur' was generally surrounded by an earth-work fortification, protected by a palisade or a stone wall. Frequent mention of capture or destruction of such 'purs', would perhaps indicate that they were numerous and were scattered all over the country.

Houses were made of wood, and bamboos served as beams of the roofs.

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During the period of the later Samhitās, the house was generally capacious enough to accommodate a large undivided Hindu family. It also had pens for cattle, rooms for storage of the grains and for performance of ritual sacrifices. Among the articles of furniture in the rooms were the seats with pillows, a bed and a sort of couch and some other things.

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4

Upanishadic Religion, Culture and Society

RELIGION AND PHILOSOPHY

Upanishadic seers devoted most of their time in knowing the ultimate truth that lies behind the visible world. They found identity between the highest principle that manifests itself' the Brahma and the individual Self, the Ātman. They sought union of the Ātman with the Brahma. Doing good and living a virtuous life were the preliminaries, and meditation the medium for this union.

Moksha: This union of the Ātman with the Brahma, which leads to liberation of the soul—the moksha, is not to be equated with un- or dis-interestedness of the person seeking it, with the world at large. It is not refutation of the world but is in fact the final flowering of the success of a successful man. To elucidate this point, it is necessary to know something of the Hindu conception of the different stages (āśrama) of life. Let us have a look at this concept.

According to Hindu scriptures, the first stage of the life of a Hindu is of Brahmachārya, *i.e.* of learning, particularly the Vedas, by a celibate student. The second is of Grāhasthya, the house-holder, when he marries, makes a home, begets children and himself offers sacrifices or has them offered. The third is of Vānaprastha, when he grows old, leaves his home and village for the forest and there he offers only a minimum of ritual sacrifices and devotes himself mainly to meditation. The final stage is called Sannyāsa, when having totally renounced the world, he becomes

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a Sannyāsin, a wandering monk, free from worldly desires and attachments and absorbed in the uninterrupted contemplation of Brahma. He no longer needs to worship God by means of material articles or even mental symbols.

From the above, it would be clear that a great part of Hindu philosophy proper, is concerned with guiding the individual during the third and the fourth stages of life and not with the first two. Not before but only after he has achieved the normal worldly aims; after his duties and obligations have been properly done as a member of the society and supporter of his family that he turns towards the task of the final human adventure and aim—the moksha.

Intermingling of Ideals: While such ideals as above, were predominant in the Upanishadic times, yet there existed a vast number of people, particularly Brāhmanas, who still followed and continued the old sacrificial rituals throughout this period. Different Śrauta and Grihya-sutras are witness to the same.

In this intermingling atmosphere, there were certain values and principles which stood prominent over all else. Virtues such as the purity of mind, forbearance, self-restraint and kindness to all were agreed values, as their practice in this life brought happiness in the next. Similarly leading a religious life and acquisition of wealth (artha) were the values (puruśārthas) and aims to fulfil which was obligatory. Efforts to secure them were not scorned upon, but were a binding for pursuance of the higher aims later in life.

THE CASTE SYSTEM

Upanishadic period witnessed a gradual hardening of the caste system in general, and deterioration of the social position of the Śudras in particular. In case somebody committed a crime, the caste of the criminal was a factor in determining the severity of the punishment. While for homicide or even theft, a Śudra received capital punishment, a Brāhmana had only his eye blinded. For abusing or hitting a Brāhmana intentionally, a Śudra was deprived of his limb, but if a Brāhmana did the same to a Śudra, he

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generally went scot-free. Arrogance of the higher caste is clearly visible here. We also see in Dharma-sutras, the beginning of the 'doctrine of defilement', through which even by touch of a Śudra, a higher caste Brāhmana was thought to have become impure or defiled.

The caste system as such, had not however, become wooden and rigid nor were the castes so strictly separated or further sub-divided as we find in later times.

No significant change occurred in the family life, in transition from the Vedic to the Upanishadic society.

POLITICAL, ADMINISTRATIVE AND LEGAL SET-UP

We know of the political, administrative and legal institutions of this period from the Dharma-sutras (600 B.C.), which deal elaborately with these aspects.

Welfare of the society as a whole, had priority over that of the individual. People were supposed to know of their individual duties and responsibilities rather that their rights and privileges—fortunately, just the reverse of what prevails now. Each person had a well recognized function in the society, which he inherited. He generally had no choice in the matter. To perform his assigned task in life (dharma) successfully, was his highest objective in life,—a duty not merely political, social or moral but also as much religious in character. On this depended not only his well-being in this life but also his salvation in the next.

Above description of the Upanishadic society looks to be closely related to that of some of the modern societies wherein interest of the society has a priority over that of the individual. There is, however, a striking difference. In the Upanishadic times, the loyalty and obedience was not to any man-made laws or to a party or an individual but to the Dharma conceived as an eternal and immutable law or order, divine in character which tolerated no human interference.

Dharma-sutras lay down the duties of the king, as of the people also. The rules applied as much to the king as even to the

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meanest subject of his kingdom. They had built-in mechanism so that the king dared not to be a tyrant, and, of course, the subjects had only duties to perform and no explicit rights. The king himself could frame no laws. If he failed to perform the duties enjoined upon him, it could lead to his expulsion from the kingdom, with a promise of adequate penalties in the next life also.

The king was supposed to possess high intellectual and moral discipline and military training. He knew the background of Vedic literature and was efficient in logic. He was to be holy in his acts and speech. He was not to live a more gorgeous life than did his teachers (gurus) or his ministers.

The king's essential functions and duties were to protect the castes and his subjects and to maintain integrity of the state against foreign invasions. He supported the learned Brāhmanas as well as the poor, needy and sick of all classes, so that none in his kingdom should suffer hunger or die of heat or cold, either because of want or even intentionally. He decided legal disputes and protected the interests of the minors until they attained maturity. He supported the widows of his soldiers and the Brāhmacharis (celibate students). He distributed, equally among his soldiers, the booty secured in battles. He prevented use of false weights and measures in his state and also looked after preservation of the fruit-bearing trees so that no damage was caused to them. He appointed officers under him to help him in the proper performance of all these functions.

The king collected taxes from his subjects. This was regarded as 'pay' received by the king in lieu of the functions he performed for the welfare of his subjects. These taxes amounted to one-sixth of the income of the subjects. If the king could not trace a stolen property in his state, he paid its value from his own treasury.

The learned Brāhmanas still occupied a high position in the society and while the king was master of all his subject, there was an exception in the case of the learned Brāhmanas who were exempt even from the usual taxes. The purohita or the domestic priest also exercised high power and privileges. The king was supposed to

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take heed of the professional advice of the astrologers and the omen-readers, as this involved the prosperity and security of the state.

After the king, his son, normally, inherited the kingship.

There were no popular assemblies like Sabhā and Samiti in the Upanishadic times, as these were superfluous in such a set-up.

Dharma-sutras enunciate clearly, for the first time, the civil and criminal laws. The Vedas, the practice of those who knew the Vedas, and the traditions were said to be the sources of law. Even the rules and customs of different castes, communities, and localities were recognized to possess the force of law. Communities of cultivators, traders, herdsmen, money-lenders and artisans had authority to lay down rules for their respective classes and these rules covered a much broader area. Penance and even out-casteing were prescribed as penalties for offences such as eating forbidden flesh, drinking an alcoholic drink or neglect of the Vedas etc.

More serious cases of crime were dealt with by the king himself or his officers. Theft was sometimes punished with death. A thief caught red-handed loosened his hair, and carrying a thick stick presented himself before the king. The king hit him with that stick with his own hands and if the thief died, he was considered to have atoned for his sin. The thief could also expiate his sin by throwing himself into a fire or could starve himself to death. Expulsion from the country was another punishment.

Penalty prescribed for deserting a wife was that the husband was to put on an ass's skin and beg from seven houses daily for a period of six months, saying 'Give alms to him who deserted his wife.'

If a learned man broke the rules knowingly, punishment for him was very much increased.

Dharma-sutras also give elaborate rules about the inheritance of the landed property. These rules applied to the Hindu society till recent times.

EDUCATION

Education was highly appreciated in this period and the highest position in society was accorded to the learned. Result was a

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high level of intellectual attainment in this period among the Brāhmanas as well as the non-Brāhmanas. Kshatriya kings like Janak, were famous for their learning, and respect was accorded to them by all including the Brāhmanas. There are instances when even the Brāhmanas learned the sacred knowledge from the Kshatriyas. Even old men had keen desire for learning. There is frequent mention of women teachers, some of whom possessed high class spiritual knowledge and wisdom. In no other period in Indian history, till modern times, women were accorded such liberty to acquire education. They, on their part, took the best advantage of it in this period and proved their worth. It is a pity that in later times, women were not even allowed to touch many of the religious scriptures.

Upanishads mention several lists of the subjects of study in those days. They include Vedas, Itihāsa, Purāna, spiritual knowledge (Brāhma-vidyā), grammar, mathematics, astronomy, military science, science of the snakes, knowledge of portents etc.

LIFE OF A STUDENT

The Sutras give detailed accounts of the life of a student. This commenced with the ceremony of initiation (upanayana) which signified formal reception of a student by the Brāhmana teacher in his own home as a regular member of his family.

Before accepting a student, the teacher, however, insisted on determining whether the candidate, wishing to learn from him possessed the necessary pre-requisites. 'Does he fulfil the preliminary disciplines?' 'Is he ripe to benefit from a contact with the teacher (guru)?' 'Does he deserve otherwise, to take a place at the feet of the teacher?' Such were the questions that the teacher considered before accepting a student. He knew that without possessing these qualities, a student could neither benefit himself nor benefit the society.

The student lived in the house of his teacher for a number of years. He served him and assisted him in his work, whether the

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craft was of a priest, a physician, magician, ascetic, potter, carpenter, charioteer or any other. He learned the techniques by practice and was guided at every step.

Moral training and character-building was as important as general education.

Vedic literature was the most important field of study and debates on it were held occasionally in large assembly halls.

Life and morals of the teachers themselves were always exemplary. They had complete identity in what they did and what they taught and preached. A teacher, thus, was a guide, philosopher and friend to his disciples.

Secrecy about Knowledge: Hindu sages and teachers never intended their teachings to become popular and they neither deny nor apologize about it. It is only in recent years that the sacred texts and the words of the ancient teachers and sages have been generally accessible. But in those days, knowledge was not to be had from books or even through general lectures, discussion or conversation. It was to be mastered through apprenticeship to a competent teacher. Philosophical wisdom, in particular, in those days, did not come under the 'item for general information'. It was a specialized learning directed to the attainment of a higher state of being. So this wisdom was guarded zealously and communicated sparingly. Furthermore, possession of such a wisdom was one of the most valuable possessions of a family heritage. It was passed on to the sons or to the most deserving pupil and in this way prestige of a learned family was kept intact from generation to generation.

Amalgamation of Knowledge: The method and language of imparting knowledge by the teacher to the students, in those days—and for centuries afterwards—was soaked in spiritual and mythical terms. This was done to facilitate understanding of the subject. Such terminology gradually became a vehicle for communication of ideas. That is why we find a complete amalgamation of religious, philosophical and the technical knowledge. It had its advantage in that in this popular form, even the most difficult concepts could be understood by the masses. But its disadvantage was that in

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later times it became difficult to find out and separate the myth from the fact, and the facts got lost in the web of the myths. This was one of the factors for the decline of the scientific investigation in India.

HEALTH AND HYGIENE

Grihya-sutras of this period lay down rules for cleanliness. Abundant use of water for daily bath, cleaning of hands, of floors and surroundings is very much stressed upon. Earthen floors were smeared over, after cleaning, with a thin layer of cowdung, which is supposed to have some sort of antiseptic properties.

AGRICULTURE AND CATTLE

People still lived in small communities in the villages, as before, and agriculture and cattle-breeding progressed further but did not substantially change from the previous times.

TRADE AND INDUSTRY

Pānini describes different coins of this period as follows: Pāna, Karshapāna, Pāda and Vāha; and different measures of weight as Adhaka, Achita, Pātra, Drona and Prastha.

House-hold goods and various implements were made of silver, copper, iron, pottery and stones. Golden spoons and brass gongs were also in use. Baskets, mats and textiles were woven. Cloth was made of cotton, linen, wool, silk and hemp. Dyeing of cloth was a flourishing industry as clothes of different colours were worn on various occasions, particularly for different sacrifices.

Grihya-sutras mention the best site for construction of residential houses. Bridges, roads, cross-ways were common feature. Two-wheeled wooden carriages driven by horses, camels, bullocks were in common use. Boats were made use of commonly for transporting goods across the rivers.

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It was this Vedic and Upanishadic society which thought, postulated and put forward in poetic terms the ideas as to how the universe was created, how its various constituents function, what was the first substance out of which everything evolved out etc. The question of the first substance and the mechanism of visible creation out of it, occupied the minds of the thinkers extensively. During the later Upanishadic period, the thinkers delved deeply into the working of nature and its general laws and put forward certain views, some of which even now, look to us fairly modern.

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5

Cosmogony (Origin of the Universe)

After man had learnt to hold his own and even to subdue large and ferocious animals, he could freely move about in jungles, mountains and plains. He was the master. And yet, when he had his belly full and was satiated, the same homo sapiens—the thinking man—thought and wondered about his environments. Various natural phenomena such as the dawn with its rising sun, journey of the sun up above across the sky, the sunset, the night with its increasing and decreasing phases of the moon and myriad of stars, the thunder, lightning, rain, the vast stretches of water in the seas—and the origin of it all, perplexed his mind.

When man speculated about the origin of the universe around him, the first idea that struck his mind was that just as he made his own house with different materials such as the pillars, stones, bricks etc. and then fixed a door here and a nail there to hang on a bow or a skin-clothing, so did perhaps, the gods or a single Almighty God made the universe and now runs it sitting somewhere high up in his cabin, looking and watching everything in it.

MECHANICAL VIEWS

Some of the poets of the Vedic period—we may call them sages or philosophers also, if we like—who composed the hymns that we find in the Rigveda, had a somewhat similar view of the origin of the universe.

According to them, 'Indra measured the six regions, made the

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wide expanse of the earth and the high doom of heaven'[1]; 'Vishnu measured out the terrestrial spaces and made fast the above on high'[2], his measuring instrument was the sun[3] and 'measurement began in front or the east'[4].

Material used for making the universe is surmised to be wood —as was the case in the building of houses in the Vedic times. In an abstract sort of way, the poet says[5] 'what was the wood, what the tree out of which they fashioned earth and heaven ?', and the answer to this query is : 'Brahma was the wood and the tree'[6].

In the following hymn,[7] the gods Indra and Soma are said to have created the universe. They supported the heaven and the earth by means of pillars.

Great is the might of yours, Indra and Soma: the first
high exploits were your own achievements.
Ye found the sun, Ye found the light of heaven.
Ye killed all darkness and the God's blasphemers.
Ye, Indra-Soma, gave her light to morning, and
led the sun on high with all his splendour
Ye stayed the heaven with a supporting pillar,
and spread abroad, apart, the earth, the Mother.

That a sky supported in such a way never falls down, as would their houses, is a perpetual source of wonder to them.[8]

In such a universe, 'Indra fixed the air in the door to the heaven'[9] and 'through the doors in the east entered the morning light'[10].

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1. RV VI 47.
2. RV I 154.
3. RV II 15; III 38.
4. RV II 15.
5. RV X 31.
6. TB 2.89.
7. RV VI 72
8. RV V 29
9. RV I 56
10. RV I 113

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The universe is well fixed-up with bands etc., so that nothing gets loosened. The following enchanting hymn praises Savitar who fixed up the whole thing[11]. It also mentions the order in which different things of the universe were created.

Savitar fixed the earth with bands to bind it, and
made heaven steadfast where no prop supported.
Savitar milked, as'twere a restless couser, air, sea
bound fast to what no foot had trodden.

Well knoweth Savitar, O child of Waters, where ocean,
firmly fixt, O'erflowed its limit.
Thence sprang the world, from that uprose the
region: thence heaven spread out and the wide earth expanded.

Then, with a full crowd of Immortal Beings, this
other realm came later, high and holy
First, verily, Savitar's strong-pinioned Eagle.
was born: and he obeys his law for Ever.

As Warriors to their steeds, kine to their village,
as fond milk giving cows approach their youngling,
As man to wife, let Savitar come downward to us,
heaven's bearer, Lord of every blessing.

Like the Angirasa Hiranyastupa, I call thee,
Savitar, to this achievement:
So worshipping and lauding thee for favour !
watch for thee as for the stalk of Soma.

Such are the ideas about the origin of the universe in some of the Rigvedic hymns. The thread that links all these above speculations is that the universe was produced mechanically by different gods, the benefactors of man.

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11. RV X 149.

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ABSTRACT SACRIFICAL VIEWS

Another view of the origin of universe in Rigveda involves the ritual of sacrifice. The following hymn[12] describes that the gods performed a sacrifice with the body of Puruśa (the Brahma, also called Prajapati, the Creator) and from different parts of His body evolved out different parts of the universe. The hymn reads as follows:

11. When they divided Puruśa, how many portions did they make?
    What do they call his mouth, his arms? What do they call his thighs and feet?

12. The Brahma was mouth, of both his arms was the Rajanya made.
    His thighs became the Vaiśya, from his feet the Śudra was produced.

13. The Moon was generated from his mind, and from his eyes the Sun had birth;
    Indra and Agni from his mouth were born, and vāyu from his breath.

14. Forth from his navel came mid-air; the sky was fashioned from his head;
    Earth from his feet, and from his ear the regions. Thus they formed the worlds.

PHILOSOPHICAL VIEWS

A few other hymns of the Rigveda given in beautiful poetic terms, contain philosophical accounts of the origin of the universe.

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12. RV X 90 (Translated by R.T.H. Griffith).

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The following examples illustrate the point.

1. From Fervour kindled to its height Eternal Law and Truth were born:
   Thence was the Night produced, and thence the billowy flood of sea arose.

2. From that same billowy flood of sea the Year was afterwards produced,
   Ordainer of the days, nights, Lord over all who close the eye.

3. Dhatar, the great Creator, then formed in due order Sun and Moon.
   He formed in order Heaven and Earth, the regions of the air and light[13].

The above hymn not only mentions the 'First Substance' from which everything else was created by the Almighty Creator, the God, but it also indicates the sequence of creation, the Eternal law and Truth being born first of all and the other entities later on.

The following hymn[14] mentions that 'Hiranyagarbha' literally, 'the gold-germ or egg ; the source of golden-light', the sun-god, the power behind all powers, came out of the primeval waters. From it sprang out the God's spirit that desired and created the universe. The First Substance in this hymn is the primeval waters.

1. In the beginning rose Hiranyagarbha, born only Lord of all created beings.
   He fixed and holdth up this earth and heaven. What God we shall adore with our oblation ?

2. Giver of vital breath, of power and vigour, he whose commandments all the gods acknowledge :

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13. RV X 190.
14. RV X 121.

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The Lord of death, whose shade is life immortal. What
God shall we adore with our oblation?

3. Who by his grandeur hath become Sole Ruler of all
the moving world that breathes and slumbers?
He who is Lord of men and Lord of cattle. What
God shall we adore with our oblation?

4. His, through his might, are these snow-covered mountains
and men call sea and Rasa his possession.
His arms are these, his are these heavenly regions. What
God shall we adore with our oblation?

5. By him the heavens are strong and earth is sted-fast,
by him light's realm and sky-vault are supported.
By him the regions in mid-air were measured. What
God shall we adore with our oblation?

6. To him, supported by his help, two armies embattled
look while trembling in their spirit,
When over them the risen sun is shining. What
God shall we adore with our oblation?

7. What time the mighty waters came, containing
the universal germ, producing Agni,
Thence sprang the God's one spirit into being. What
God shall we adore with our oblation?

8. He in his might surveyed the floods containing
productive force and generating worship.
He is the God of gods and none beside him. What
God shall we adore with our oblation?

9. Ne'er may he harm us who is earth's Begetter
nor he whose laws are sure, the heaven's Creator,
He who brought forth the great and lucid waters. What
God shall we adore with our oblation ?

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10. Prajapati ! thou only comprehendest all these created
things, and none beside thee.
Grant us our heart's desire when we invoke thee :
may we have store of riches in possession.

In the following hymn[15], a predominantly philosophical thought is mixed up with the mechanical one. Brahmaspati, the Creator, is represented as a black-smith working with the blast of air smelting and creating the universe.

2. These (all beings) Brahamaspati produced with blast and
smelting, like a smith.
Existence, in an earlier age of gods, from Non-existence
sprang.

3. Existence, in the earliest age of gods, from Non-existence
sprang.
Thereafter were the regions born. This sprang from the
productive power.

4. Earth, sprang from the Productive Power; the regions
from the earth were born,

Here is another hymn[16] in which the poet just wonders as to how the Creator would have created the universe. He even asks others to ponder over this question.

2. What was the place whereon he took his station?
What was it that supported him? How was it?
Whence Viśvakarman, seeing all, producing the earth,
with mighty power disclosed the heavens.

3. He who hath eyes on all sides round about him,
a mouth on all sides, arms and feet on all sides,

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15. RV X 72.
16. RV X 81.

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He, the Sole God, producing earth and heaven, weldth
them, with his arms as wings, together.

4. Ye thougtful men inquire within your spirit whereon
he stood when he established all things.

And this last is the most beautiful hymn[17] about the origin of the universe. Here the philosophy of the Vedic thinker is at its upper-most limit. He humbly mentions his own thoughts, but cannot vouch-safe for their truth.

1. Then was not non-existent nor existent: there
was no realm of air, no sky beyond it.
What covered in, and where? and what gave shelter?
was water there, unfathomed depth of water?

2. Death was not then, nor was there aught immortal :
no sign was there, the days and night's divider.
That one thing, breathless, breathed by its own
nature ; apart from it was nothing whatsoever.

3. Darkness there was : at first concealed in
darkness this all was indiscriminated chaos.
All that existed then was void and formless :
by the great power of warmth was born that Unit.

4. Thereafter rose Desire in the beginning, Desire,
the primal seed and germ of spirit.
Sages who searched with their heart's thought
discovered the existent's kinship in the non-existent.

5. Transversely was their severing line extended:
What was above it then, and what below it?
There were begetters there were mighty forces, free
action here and energy up younder.

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17. RV X 129.

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6. Who verily knows and who can here declare it,
Whence it was born and whence comes this creation ?
The gods are later than this world's production
Who knows then whence it first came into being?

7. He, the first origin of this creation, whether he
formed it all or did not form it,
Whose eye controls this world in highest heaven
he verily knows it, or perhaps he knows not.

Scanning the above-mentioned hymns from the Rigveda, we see that many of the poet-philosophers of the period regarded universe to have been created either out of the primeval waters (RV X. 121) or through the body of Puruśa (RV X. 90), the One Absolute. Both these speculations regard only one'First Substance' as the source of all that followed.

How the matter evolved out of the 'First Substance', we shall see in a later section.

These are the ancient Indian speculations about creation of the universe. Let us see now what the people in other lands thought about this subject.

ANCIENT MESOPOTAMIAN COSMOGONY

Babylonian Epic of Creation: This epic composition[18], a product of the priests of Babylon, can be dated between 2169-1870 B.C., the period of the first Babylonian dynasty. The legend in it states that in the beginning only two entities existed: Apsu, the deity of fresh water, and Tiamat, the female dragon of Chaos and personification of the primeval salt water seas. From their union sprang the gods of heaven and earth who rebelled and sought to create an orderly universe. In the great conflict with the female dragon Tiamat, both Anu, the heaven god, and Ea,

18. *Enc. Brit.* (1953), Vol. 6, p. 651-2.

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the water god, fled before her. Only Marduk, son of Ea, went forth to the battle. In her determination to destroy the gods of light and order, Tiamat created eleven monsters and Kingu, her husband was their leader. Marduk defeated Kingu and later Tiamat also and had the eleven monsters bound and chained to the stars which are identified as the constellations Hydra, Leo, Scorpio etc.

Marduk then divided the body of Tiamat and with half of it he made the canopy of heaven and with the other half of it he made the abode of the Apsu. He fixed the movements of the planets in the ecliptic, the motions of the moon and the positions of the signs of zodiac. Man was created by Ea, from the blood of the slain Kingu.

ANCIENT GREEK COSMOGONY

According to ancient Greek poet Hesiod, at the beginning there was chaos: then came Gaia, the broad-bosomed earth, and next, Eros, loveliest of the gods, who compels the senses of the mortals and the immortals alike, and melts the strength of their limbs.

Chaos engendered both Darkness and Black Night, and the Air and Day called respectively as Aether and Hemera. From their union sprang Gaia which first created of her own accord the starry heaven, the high mountains and Pontus, the sea. Then, as the bride of Uranus, she brought forth Oceanus, the stream that encompasses the earth, Cyclopes, the god of lightning, Tethys, the goddess of the sea and also a long series of children, some of them mighty monsters, and others of an almost allegorical description.

From the marriage of Oceanus and Tethys sprang fountains and the streams. The sun-god, the moon-goddess and the Dawn were born to two other children of Heaven and Earth. Dawn is united to her cousin Astraeus, god of the stars, and the Winds, the Morning-star and the rest of the luminaries were born of that marriage.[19]

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19. *Greek Thinkers : A History of Ancient Philosophy* by Theodor Gomperz, Vol. 1. (Eng. trans) Lond. John Murray, Albemarle St. W (1964) 7th impression, p. 39.

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COSMOGONY IN THE BIBLE

The first chapter of Genesis in the Bible gives a cosmogenic account. God created the world in six days and rested on the seventh. He created the light, the heaven, the sea, the earth and its vegetation, the stars, the birds, the fishes and land animals and the man.

The firmament is supported by mountains, the pillars of heaven, whose unshakable foundations go down to the very bottom of the great void. This void is a kind of cosmic ocean in which the world swims and which feeds its springs and its rivers.

The earth itself is a flat disc and would have been in constant danger of being engulfed by the void from which it had sprung, were it not for God's covenant with Noah that never again would there be a flood to destroy this earth.

MEDIEVAL AND MODERN COSMOGONY

Urge to know as to how the universe came into existence, was not only present among the ancient thinkers, but it also existed in medieval times and it still haunts the modern scientists and philosophers.

NEWTON'S COSMOGONY

Newton in 1692 said[20]: 'It seems to me that if the matter of our sun and planets and all the matter of the universe, were evenly scattered throughout all the heavens, and every particle had an innate gravity towards all the rest, and the whole space throughout which this matter was scattered was finite, the matter on the outside of this space would, by its gravity, tend towards all the matter on the inside, and by consequence fall down into the middle of the whole space, and there compose one great spherical mass. But if the matter were evenly disposed throughout an

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20. *Enc. Brit.*, Vol. 6, p. 488.

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infinite space, it could never convene into one mass, but some of it would convene into one mass and some into another, so as to make an infinite number of great masses, scattered great distances from one another throughout all that infinite space. And thus might the sun and fixed stars be formed, supposing the matter were of a lucid nature.'

KANT'S COSMOGONY

Kant[21] in 1755, followed Newton in regarding a limitless chaotic primordial matter as the raw material of which the universe has been formed, as also in supposing gravity to be the agency through which this formation took place. He imagined that, as a result of mutual gravitational attractions, primeval atoms continually fell in upon one another and so became hotter, just as a bullet does on striking the target. He imagined that the collisions of these atoms generated not only heat but also rotation. As the atoms collided the nebula not only got hotter and hotter, but also began to rotate and spun faster and faster until at last splashes of matter were thrown off from its equator, much in the manner in which slpashes of mud are thrown off a bicycle wheel. These splashes of matter formed a continuous rotating ring which encircled the nebula just as Saturn's rings encircle Saturn. The ring finally condensed into a planet and by many repetitions of the process the sun's family of planets was born out of its body.

LAPLACE'S COSMOGONY

Laplace in 1796, propounded the system of cosmogony, which, under the general name of the Nebullar hypothesis, held the field for a full century. Laplace's cosmogony may be briefly described as that of Kant with the mistakes left out.

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21. *Enc. Brit.*, Vol. 6, p. 488.

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TIDAL THEORY OF COSMOGONY

In 1950's the Tidal theory[22] of cosmogony held the field. It explained origin of the solar system, the planets and their satellites to an exceptionally close approach between our sun, then a normal single star unaccompanied by planets, and a passing star. The closer the approach of a wandering star, other things being equal, the higher would be the tides raised on the surface of the sun; but unless the approach was very close indeed, the tides would subside as the star which caused them receded. If the passing star came to within a distance of a few radii, generally about three, of the sun, the tides would take the form of two long arms of gas ejected from opposite points of the sun's surface and these would not necessarily subside as the disturbing star receded. Under the action of gravitational instability condensations would form in these long gaseous arms and calculation shows that the masses of these condensations would be just about the order of the magnitude of the observed masses of the planets.

If the tidal cataclysm of this kind can explain the birth of the planets it can obviously, in general term at least, explain the birth of satellites out of these planets.

Commenting upon various theories of the creation of the universe, Russell (1949) said[23]:

"I think, we ought provisionally to accept the hypothesis that the world had a beginning at some definite, though unknown date."

"Are we to infer from this that the world was made by a Creator. Certainly not, if we are to adhere to the canons of valid scientific inference. There is no reason whatever why the universe should not have begun spontaneously, except that it seems odd that it should do so, but there is no law of nature to the effect that things which seem odd to us must not happen. To infer a Creator is to infer a cause, and causal inferences are only admissible in

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22. Jeans, J.H. *Problems of Cosmogony and Stellar Dynamics.*
23. Russell, B. (1949) *The Scientific Outlook.* Allen & Unwin Ltd. London p. 122.

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science when they proceed from observed causal laws. Creation out of nothing is an occurrence which has not been observed. There is, therefore, no better reason to suppose that the world was caused by a Creator than to suppose that it was uncaused; either equally contradicts the causal laws that we can observe."

"Nor is there, so far as I can see, any particular comfort to be derived from the hypothesis that the world was made by a Creator. Whether it was or whether it was not, it is what it is."

Since the last two decades, a tug of war is going on between the two most modern theories of creation of the universe: the big bang theory and the steady state theory.

Any new theory about the origin of the universe, put forward from any corner of the world, is still a much-discussed news among scientists and the non-scientists alike. When or whether we will ever know the final answer, is yet to be seen. Just now, as said by an eminent astronomer, "We are in the kindergarten stage" so far as the knowledge of cosmogony is concerned.

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6

Cosmology (Structure of the Universe)

DIVISIONS OF THE UNIVERSE

Vedic people generally regarded earth, air and heaven as the three divisions of the universe. While sometimes air and heaven are collectively called as sky, in other places air itself (āntriksha) is even subdivided into two or three subdivisions. In the three-fold subdivision of the air, only the lower two are said to be perceptible to human beings and it is here that lightning, rain and the wind reside. In the two-fold subdivision of the air, the upper one is adjacent to the heaven.

While the human beings and other animals live on earth, the gods live in the heaven, invisible to the eyes of the human beings.

SHAPE OF THE EARTH

Earth was regarded as circular like a wheel. This is evidenced by the following hymn in the Rigveda[1], in praise of god Indra :

> Who to his car on both sides securely has fixed the earth and heaven as with an axle.

In another place in the Rigveda[2], earth is considered to have the shape of a bowl, the same as is of the heaven—the two great bowls of the earth and the heaven being face to face with each other.

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1. RV X 89.
2. RV III 55.

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DISTANCE BETWEEN HEAVEN AND EARTH

Atharvaveda[3] describes it as a 'thousand days journey for a horse'. In a later scripture[4] this distance is mentioned as just equal to that when a thousand cows stand one on top of the other.

SUN'S DIURNAL JOURNEY

While the sun is said to 'travel fast' in the heaven during the day time, the following hymn perhaps, vaguely mentions what happens to it at night. It says[5] about Savitar, the sun :

To the three spheres of light, thou goest Savitar
and with the rays of surya thou combinest thee.
Around both sides thou encompassest the night.
Yea, thou, O God, art Mitra through thy righteous laws.

'Around both sides...' has been interpreted to mean that it reappears after the night.

The sun at night is also mentioned as shining upwards, while during the day time it turns downwards towards the earth[6].

Maintaining order and regularity (rita) in the universe was considered a job of the highest gods.

ORIGIN OF MAN

Vedas consider all men to have descended from the 'First Man' the Vivaśvat's son Manu[7] or Yama Vaivaśvata, who with his twin sister Yami produced the human race.

In other places, Agni[8] is said to have begotten Angirases, the

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3. AV X 8.
4. *Panchavimsa Brahmana* 16.8 ; 21.1.
5. RV V 81.4.
6. AB. 3.44
7. RV X 63
8. RV I 96

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semi-divine ancestors of the priestly families, from whom the human race originated. Certain other human families are said to have independently descended from other gods, through their founders like Ātri, Kānva etc.

Heaven and Earth were regarded as 'Universal Parents'. Heaven fertilizes the earth by the descent of moisture and light, and earth, the mother produces all vegetation etc.[9]

COSMOLOGY OF AGNI PURĀNA

Some of the Purānas describe cosmology in great detail. This is essentially mythical, yet interesting nonetheless. Majority of the Purānas in their present form cannot be placed earlier than the Gupta period. Even though it does not come under the Vedic period, yet it has been taken up here because of interesting comparisons.

Agni Purāna describes structure of the earth, distance between it and the heavenly bodies, different mythical heavenly abodes (lokas) etc. as follows.[10]

Earth: Extent of land on the surface of the globe is said to be 7000 yojanas, the height or dimension of which between the poles is 10,000 yojanas (A yojana is equal to three miles).

In the interior of the globe and beneath the earth's surface are the seven nether regions (patālas) which are respectively known as Atāla, Vitāla, Nitāla, Gabhastimat, Mahākshya, Sutāla and Agrya. Soil of these sub-terranean regions consists of sand, stone and gold and these are black, brown and reddish in colour. Only the demons dwell in these regions. Beneath these regions is the primordial serpent Shesha who balances the earth on its hundred hoods.

Distance between the Heavenly Bodies and the Earth: Nearest to the earth is the sun; next comes the moon and then the belt

9. RV V 84.

10. *Agni Purana*: A prose English translation in 2 vols. Edited and published by Manmatha Nath Dutt. Printed by H.C. Das, Elysium Press, 40 Nayan Chand Dutt St., Calcutta. Ch. CXX, p. 477.

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of the fixed stars. Distance between each of these is 800,000 yojanas. Farther away are the Venus, Mars, Jupiter and Saturn, each of which has a distance of 200,000 yojanas between them. Distance between the farthest constellation Ursa major (Saptarishi) and the Saturn is 100,000 yojanas.

Obviously these distances are based on the assumption that the smaller the apparent size of the heavenly body, the farther away it is from the earth and *vice versa.*

Mythical Heavenly Regions or Abodes: The pole star (Dhruva), is 800,000 yojanas distant from the Ursa major (Saptarishi) and forms the apex of the region known as the Trai-lakhya. Region known as the Mahā is tens of millions of yojanas distant from the Pole and herein dwell the persons who have witnessed a full cycle of time from the creation of the world to its dissolution at Pralāya. Region known as the Jana-loka is at a distance of 2 million yojanas from the latter and herein dwell the sages, such as Sanaka etc. Region of Tapa is eight million yojanas distant from that of Jana-loka and here the Vairajas are the presiding deities. Region of the Satya is 96 million yojanas distant from the latter. Region which is never visited by death is known as the Brahma-loka or the region of deathless disembodied celestials.

These regions form, as it were, the exterior cover or shell of this egg of the universe, which in its turn is encrusted by ten-fold layers of water, fire, wind, ether and the earth—just like the body of any other organic being.

'Other Worlds': Agni Purāna says that, 'this nature is inconceivable and baffles all measurement or comprehension. Innumerable are the eggs of such worlds and systems which are constantly hatched into their fiery existence under the wings of the Universal Mother.'

Such is the cosmology of Agni Purāna—fully immersed in myth and imagination. It is interesting to compare this account of the different regions of the universe in which abide personalities of different grades of piousness and purity with the spheres around the earth as given by the Greek thinkers like Plato and Aristotle. Greek account is completely rid of any myth and

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many a time the spheres of the Greeks are intended to clarify the hypotheses. Whether they really succeed, we will see later.

After having seen the ancient Indian cosmological notions, let us now have a look at the cosmological notions held by the peoples of other ancient civilizations.

CHINESE COSMOLOGY

According to one of the oldest Chinese views, the upper vault of the fixed stars is a hemispherical cover which revolves over a square earth. The sun and the moon have their own motions also, but they are carried along as 'the ants are carried over a moving stone'.

According to another view, the heaven is like a hen's egg, and the earth in it like the yolk. The total diameter of this egg of the heaven is 2,032,300 li.

BIBLICAL COSMOLOGY

The Bible considers universe to be divided by earth into an upper heaven and a lower watery region. Beneath the latter is the region where the dead live.

Light is considered to have been created earlier than the sun and it exists independently. The sun, the moon and the stars follow obediently the course on which God set them. Heaven is so close to the earth that birds could fly upto it. God looks down from heaven upon men and his other creatures. Rain is poured down by God from huge vessels and it comes down through windows in the heaven. Snow, hail and storms have their own specific compartments up above and they come down at God's commands.

GREEK COSMOLOGY

While the Biblical, the Chinese and even the Vedic Indian

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views are mythical, those of the Greek thinkers of the sixth and fifth century B.C. were completely rid of it. Some of their views clearly indicate a keen sense of observation and deduction.

Thales: The earliest of the Milesian thinkers (born C. 624 B.C.) considered universe to be like a hemi-spherical ball of air whose concave surface is the sky and the plane surface like a circular disc, our earth. Such a universe floats in the upper waters and the earth floats in the lower waters.

Anaximander: To him (fl. C. 570 B.C.), the earth is a cylindrical column, whose diameter at the base is equal to a third of its height and whose upper part, which we inhabit, bulges out slightly. It is held in equilibrium because it is equidistant from the boundaries of the universe. It needs no support and is suspended in air.

The earth is encircled by a series of vast rings so that it is like the innermost kernel and its surface is covered by water, air and the fire in that order as 'the tree is covered by its bark'.

The sun, the moon and the stars are the glimpses of the fire seen through the holes in the outer rings—the most distant ring being that of the sun and the nearest that of the stars. Eclipses of the sun and moon are the temporary obstructions in the holes of the sun and the moon-rings.

Anaximander also held that our universe was not the only one and that there were a host of others also.

Of the organic creation, he said that the first animals on earth sprang from sea-slime. This, he guessed from the observation that the animal body consisted of solid and fluid components. He further said that the ancestors of the human race had their origin in the bellies of the fish.

Anaximenes : He (fl. C. 546 B.C.) also considered earth to be a flat disc which sloped upwards towards the north. For him, this was the explanation of the apparent disappearance of the stars, as they revolved about the earth. He also believed that the sun after its setting did not pass under the earth but skirted the horizon where it was hidden from view by high mountains, to rise again in the east.

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He thought that the moon shone with its own light and that the sun, the moon and the planets were of fiery nature and were supported by air. The fixed stars were, however, attached like nails to the celestial sphere which was made of a crystalline substance. He substituted spheres in place of the rings of Anaximander.

Anaximenes was, however, the first among the Greek thinkers to distinguish between the planets and the stars.

Xenophenes: He thought that a new sun shone every day and it was replaced by another the next day. Similarly the new stars at night were also born daily. The stars moved in a straight line above our earth. The stars and the sun were sort of clouds that arose as collections of evaporations from the sea. The earth extended indefinitely beneath us.

Heraclitus: He (fl. 505 B.C.) agreed with Xenophenes in considering stars as accumulations of evaporation from the earth, seas and the winds. He considered these accumulations to be shaped like boats or bowls which opened towards us, and whenever they turned about, eclipses were caused. Sun was hot because its boat was nearer to the earth. A sun was born daily and the stars like lamps were put on and off daily.

Permenides: He (born 540 or 514 B.C.), unlike earlier Ionians viewed earth as a sphere which was uncreated, indestructible, continuous, immovable and complete. Around this sphere of earth were the concentric bands; the band of pure fire or light being the most distant. Other intermediate bands were mixed with darkness and light. The stars were the luminous parts of these bands.

Anaxagoras: He (fl. 460-450 B.C.) thought that the stars were born as a result of tearing away of the stones from the earth by the ether. They shone because they had caught fire due to rapidity of their motion.

Empedocles: The universe of Empedocles (fl. 460-450 B.C.) was egg-shaped. Increasing speed of the heavenly motion was responsible for fixing the earth in the centre of the universe and for keeping it there. He said that length of the day and the night was gradually decreasing because of the increasing speed of motion. In the beginning, when man first appeared on this earth,

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day was equal to ten months of Empedocles' times.

Pythagoras: His (C 540 B.C.) cosmology, based as it is on numbers rather than on 'Ionian fire and water', is more of a mathematical astronomy and for the same reason less primitive.

Pythagoreans considered that the centre of the universe was occupied by a fire, around which revolved ten heavenly bodies. The nearest to the central fire was the counter-earth, which was invisible because it was on the opposite side of the central fire. The central fire itself was invisible because the inhabited half of the earth was always turned away from it. Next to counter-earth was the earth and then came the moon, mercury, venus, sun, mars, jupiter, saturn and the sphere of the fixed stars. Relative distances of these bodies were in simple arithmetical and musical proportions. Two cosmic regions could be distinguished, one above and other below the moon. The below-moon region (sub-lunary) was degenerate and corrupt and the above-moon region was incorruptible (Comparable with the Purānic cosmology of the Hindus).

The counter-earth of the Pythagoreans was meant to explain eclipses which occurred, according to them, by the interposition of this opaque body between the central fire and the moon or the sun. Pythagoreans considered earth to have a spherical shape. The same was the opinion of Permenides also.

Leucippus and Democritus: They thought in terms of atoms. They considered universe to be formed out of the minutest particles, the atoms, whose different arrangement and combination gave different characteristics to different things.

According to them, the earth was shaped like a tambourine or a disk and the planets and the stars revolved around it. Moon was closest to the earth and the sun the farthest. The heavenly bodies, according to them, were afire because of the rapid motion with which they moved.

Plato: According to him (428- or 27 to 348 B.C.), the universe, the heavenly bodies and the earth were spherical in shape. The earth was in the centre of them all. It was immobile. Other celestial bodies circled around it at various distances from it. The fixed stars were the most distant. The moon which shone with

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the reflected light of the sun was closest to the earth, with the planets venus, mercury, mars, jupiter and saturn coming next in that order. The sun, venus and mercury revolved at equal speeds, while other planets and stars moved faster. They all moved in the same direction except the mars which followed a retrograde path.

Plato postulated four concentric spheres in the universe that were made up of earth, water, air and fire. The first three spheres constituted the sub-lunary world (below moon), while the fourth *i.e.* of the fire, contained the stars.

Aristotle: His (384- or 83 to 322 B.C.) universe was very much like that of the Pythagoreans and of Plato—the central earth surrounded by spheres of water, air and fire, the sub-lunary and supra-lunary regions, the distances of various celestial bodies from the earth, all of which followed circular paths around the immobile central earth. About its immobility he adduced the now-familiar example of the landing of an object on the same spot from which it was thrown upwards.

In trying to explain the celestial phenomena, he added more and more compensatory spheres around the earth and extended their number to a grand total of fifty-six.

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Matter and its Creation

In the Upanishadic period, we find the Hindu sages turning away from the sacrificial rituals and devoting much of their attention to understanding Self (Ātman) and the ultimate essence of the universe. Concentrated thought, closer observation and deeper comprehension resulted in their realising the fact, that the vast variety of substances and materials in the universe in the ultimate analysis, were all made up of small, indivisible pramānus of different types.

Period between 800 B.C. and the beginning of the Christian era, is notable for the growth of such thoughts and philosophies in India. They reveal the coherent way of thinking of the seers of that period. There is no demarcation between what we now call as religion, philosophy and science. These thoughts show how different disciplines were utilized to explore the fundamental questions. Such an amalgamation of different aspects of knowledge—though it is gradually being realised is to the best advantage of mankind—in the beginning, led many foreign scholars to attach no significance to the scientific theories expressed in this way. But those who have now rid themselves of the initial bias, are coming to the conclusion that such scientific theories though not based upon regular experiments in the laboratory, nonetheless, are worthy of consideration. Kanāda, the ancient philosopher-scientist had expounded one of such theories.

KANADA

Kanāda, also known as Aulukya and Kaśyapa, is said to be

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the son of the sage Uluka. He lived around sixth century B.C. at Prabhāsa in Allahabad. He was the pupil of Soma Śarmā, who was said to be an incarnation of Lord Śiva. Kanāda lived the life of an ascetic and for his daily bread collected grains from public streets. That is why he came to be known as Kanāda, Kanabhuk or Kanabhakśa, meaning one who feeds on particles. He, according to some Buddhist texts, is also called Aulukya, the owl, on the basis of the fact that he used to meditate in a dense forest during the day time and wandered about for food at night.

Mythological story says, that by such severe austerities, he pleased Lord Śiva, the Omniscient, who appeared before him in the form of an owl and imparted to him knowledge about the constituents of which the universe was made up of and also asked him to make a treatise, embodying those truths for the benefit of mankind. Thus Kanāda composed the Vaiśeshika sutras, the first systematic work of the Vaiśeshika philosophy, whose ultimate aim is liberation of the soul through better understanding of the universe.

MATTER ACCORDING TO VAIŚESHIKA

According to Kanāda, everything in the universe is made up of pramānus, the real entities which are obtained when a thing is divided and subdivided until further division is not possible. Pramānus combine together in various fashions and it is by their combination that they give rise to creation of the universe and its contents which we see and perceive. Elaborate discussion of the peculiar characteristics (Vaiśesha means peculiarity) of the different kinds of pramānus and their various combinations give the name Vaiśeshika to this philosophy.

After Kanāda, Praśastapāda, in the fifth century A.D., wrote a remarkable and comprehensive commentary on the Vaiśeshika sutras. It is called Praśastapāda Bhaśya or more commonly Padārtha dharma-samgraha. In later times many commentaries were written on this work itself, namely those of Vyomavati of

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Vyomāchārya, Kirnavali by Udayanāchārya, Kandali by Śridharāchārya and Setu by Padmanābha Miśra.

SIX CATEGORIES (Padārthas)

According to Vaiśeshika, everything in the universe can be described under six categories. These are:

1. Substance (Dravya)
2. Quality (Guna)
3. Action (Karma)
4. Generality (Sāmānya)
5. Individuality (Vaiśesha)
6. Inherence (Samavāya)

Of the category Substance, there are nine sub-varieties. These are:

1. Earth (Prithvi)
2. Water (Apa)
3. Fire (Teja)
4. Air (Vāyu)
5. Ether (Akāśa)
6. Time (Kāla)
7. Space (Dig)
8. Self (Ātman)
9. Mind (Mana)

Characteristic features of the above different sub-varieties of the category Substance are as follows :

EARTH (Prithvi)

Earth has the qualities of colour, taste, odour, touch, number, dimension, isolation, distance, proximity, gravity, fluidity and faculty.[1]

Of these qualities, smell belongs to earth alone and is, in consequence, its distinctive feature. It is neither fragrant nor non-

1. *Padārtha dharma samgraha* (PDS) III 1, 36

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fragrant. Colour of earth is manifold such as white etc.; its taste is of six kinds such as sweet etc.; its touch is neither too hot nor too cold.

Earth is of two kinds: (1) Eternal and (2) Evanescent.

In the form of atoms it is eternal, and in the form of products evanescent.[2] The latter is qualified by such an arrangement of its component particles as tends to make it solid or rigid.

Earthy products and objects may be those that are (1) born out of womb—viviparous and oviparous, such as is the man, the different animals, birds etc., and those that (2) do not take birth in the womb such as the vegetables, trees, stones, gems, clay etc.

Sense organ that makes the earthy products and objects perceptible is the olfactory organ in the nose which percepts the smell, the characteristic of the earthy products.

WATER (Apa)

Water has the qualities of colour, taste, touch, fluidity, viscidity, number, dimension, separateness, conjunction, disjunction, distance, proximity, gravity and faculty.

Colour of water is white, its taste is sweet, its touch is cool. Viscidity and fluidity belong to water alone and they are its characteristic features.[3]

Like earth, water is also of two kinds: (1) Eternal and (2) Non-eternal.

Sense organ to perceive water is the tongue, the organ of taste. It serves to make taste perceptible to all living beings. Watery objects exist in the shape of rivers, oceans, the moon, hails etc.[4]

FIRE (Teja)

Fire is endowed with colour, touch, number, dimension,

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2. *Ibid.* Commentary by Jha, G.N. (1916)
3. PDS IV 11.37
4. *Ibid.* Commentary by Jha, G.N. (1916).

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separateness, conjunction, disjunction, distance, proximity, fluidity and faculty. Its colour is white and brilliant. Its touch is hot only[5] and that is its distinctive feature.

Fire also is two-fold: (1) in the form of atoms and (2) the products.

Sense-organ of its perception is the eye which makes colour perceptible to all living beings.

Fiery objects are of four types: (1) Earthly (2) Heavenly (3) Stomachic (organic) and (4) Mineral. The Earthly fire is that which consists of flames produced by wooden fuels and is capable of accomplishing cooking, burning, softening, sweating etc. The Heavenly fire is that which is produced by watery fuel and exists in the form of the sun, lightning etc. The Stomachic fire is that which brings about digestion of food that is eaten. The Mineral fire exists in form of gold and other metals.

Experience of taste etc. in these minerals belongs to an other substance compounded with the fire molecules.[6]

AIR (Vāyu)

Air has the following qualities: touch, number, dimension, isolation, conjunction, disjunction, proximity, distance and faculty.

Touch of air is neither warm nor cold and is not due to burning.[7]

Air is also of two kinds: (1) in the shape of atoms and (2) their products.

Sense organ of perception of air pervades all over the body and is that of touch.

Airy object is that which is actually perceived as air, the substratum of all touch. Its existence is indicated by touch, sound, steadiness and shaking. It moves horizontally and is capable of moving and holding the clouds and other things. Though air is

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5. PDS IV 3.38.
6. *Ibid.* Commentary by Jha, G.N. (1916).
7. PDS. IV 4.39.

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not visible, yet its numerousness is inferred from the collapse of winds—this collapse being due to collision of two contrary winds blowing with equal velocity.

Breath is the air in the body. It serves the purpose of moving about the various fluids, secretions and other materials in the body. This air in the body is called as Prāna, Apāna, Samāna, Udāna and Vyāna, on account of its various functions (of moving up, down etc.)[8]

PRAMĀNU

According to Vaiśeshika system, pramānu (atom) is the ultimate and indivisible particle of each of the aforesaid sub-varieties of substance, namely of earth, water, fire and air.

Collectively speaking, chief characteristics of the pramānus are as follows:

1. They are eternal, indivisible and partless. A pramānu possesses both the smallest and the shortest possible dimension.

2. Each of the four kinds of pramānus possesses its specific attributes: earthly pramānu has smell, airy the touch, watery the taste, and fiery the colour. These attributes inherent in the pramānus are also eternal—except in the case of earthly pramānus where they remain changing due to chemical action (pāka) caused by application of heat.

3. They are both collectively and individually imperceptible through any of the sense organs. Lack of magnitude and manifested colour makes them imperceptible to vision, and similarly lack of magnitude and manifested touch makes them imperceptible to touch and so forth.

4. Each of the four different types of pramānus possesses quiddity (essence of a thing), which differentiates one from the other.

By themselves the pramānus cannot produce anything, yet they are the ultimate material cause of the universe. A composite of

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8. *Ibid.* Commentary by Jha, G.N. (1916).

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them is formed by the conjunctions which are brought about by motion, which itself is the cause of conjunctions and disjunctions. Such a motion is very essential both for the production and destruction of the sensible world.

What produces the original motion in the pramānus? Vaiśeshika assumes the presence of a super-human power, the Divine Will, conscious and capable of producing such a motion. With the help of this motion pramānus group together to form bigger parts (avayavas) and composites.

ETHER (Ākāśa)

Ākāśa has the following qualities : sound, number, dimension, separateness, conjunction and disjunction.[9]

Sound is its distinctive attribute.

Ākāśa is all-pervading (vibhu) and this points towards its dimension being the largest or highest. And as ākāśa is spoken of as the cause of sound it follows, that it has conjunction and disjunction.

Thus being endowed with qualities and not being located in anything else, ākāśa is regarded as a substance. And as it has no cause, either homogeneous or heterogeneous, it is eternal.

Sense organ of its perception is the ear.

In trying to prove that sound is a quality of ākāśa, it was argued that (1) Sound cannot be the property of those substances that can be touched, (2) It cannot be regarded as belonging to the soul, (3) It cannot be the quality of space, time and mind. And thus the only substance to which it could belong as a quality and be a distinguishing feature of, is ākāśa. As the distinguishing feature of sound is common to all ākāśa, this is regarded as one only. And so from its unity follows its individual separateness or isolation.[10]

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9. PDS. IV 6.41
10. *Ibid.* Commentary by Jha, G.N. (1916)

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CRITICISM OF VAIŚESHIKA

The above-mentioned Vaiśeshika classification or division of the material substances of the universe, into five sub-varieties of the category Substance (Padartha), has been criticized by many Western scholars. This criticism, however, is due to some misunderstanding about the Indian terminology and its inapt translation into English language. This has now been made clear by the Indian scholars. I will quote the words of Jha (1916) in this regard. He said:[11] "Hindus have been taxed with postulating five 'elements'. It seems that the charge is not well-founded. People who make this charge apparently use the term 'element' in the chemical sense of a substance that cannot be further analysed. Are the 'earth, water, fire, air and ākāśa' of the Vaiśeshika such unanalysable substances? On referring to any Vaiśeshika manual, it will be clear that what is ordinarily known as 'earth' is not regarded by the Vaiśeshika to be an 'element' in the technical sense. If it were so regarded then alone could the Vaiśeshika view be stigmatised as primitive and unscientific. The touch of earth in the pure state is said to be 'neither hot nor cold' ; so also the touch of air. When asked why ordinary earth and ordinary air are found to be very far from neither hot nor cold, the Vaiśeshika explains that this is due to the earth and air being mixed up with particles of fire or water, which make them feel hot or cold. From this it is clear that what is regarded as 'element' is not the earth etc. as we know and see them; but as they exist in their original and pure state, unmixed with any other substance, that is to say, in their atomic condition. Is it, then very unscientific to regard the atoms of earth, fire etc. to be 'elements' ? What is the atom of earth but an ultimate material substratum of odour. Can this be analysed further?

"Furthermore, the name that the Hindu gives to these substances is only 'bhuta' ; and it is not fair to translate 'bhuta' as 'element'

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11. Jha, G.N. (1916) Translation and Comments on *Padārtha dharma samgraha*. Introduction, p. ii.

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and then tax him with being unscientific. What the Vaiśeshika means by saying that these are the five 'bhutas' is that there are five states of matter, solid (earth), liquid (water), gaseous (air), luminous (fire) and etheric (ākāśa). Is this division absolutely unscientific ?"

Other subvarieties of substance namely time and space will be discussed in a later chapter. Mind and soul need no discussion.

Now we will move on to the other five categories of matter and see how Vaiśeshika system describes them.

QUALITY OR ATTRIBUTE (Guna)

Quality, according to Vaiśeshika, is that which naturally resides in substances, does not contain a quality in itself and is not an independent cause of conjunction or disjunction.

There are in all twenty-four qualities. These are: colour, taste, smell, touch, number, measure or quantity, separateness, conjunction, disjunction, priority, posteriority, understanding or cognition, pleasure, pain, desire, aversion, volition, gravity, fluidity, viscidity, potentiality (velocity, elasticity and impression), merit, demerit and sound.

They need no discussion here as they are self-explanatory.

GENERALITY OR COMMUNITY (Samanya)

It stands for the property that tends to make certain things to be regarded as 'similar'. Hence it is the common characteristic belonging to many individual entities.

Generality is of two kinds: (1) the higher and (2) the lower.

The higher generality extends over the largest number of things and serves as the basis of comprehensive cognitions. Thus, in the case of a number of totally different things, as for instance, pieces of leather, of cloth, of blanket and so forth, if all of them are possessed of the same quality of blueness, with regard to each one of these we have the notion that 'it is blue'. In the same manner,

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in the case of totally different categories such as substance, quality and action, we find that with regard to each one of them we have the notion that 'it exists'. This all-inclusive notion could not but be due to something apart from the three categories themselves, and this something is what we call higher generality.[12]

The lower generalities pertain to substances, qualities, actions and so forth and they extend over a limited number of things. As these give rise to inclusive as well as exclusive notions, they are regarded as generalities as well as individualities. For instance, 'substance' is a generality inasmuch as it serves as the basis of an inclusive notion with regard to such mutually different things as earth, water and the like, and it is an individuality inasmuch as it serves as the basis of notion exclusive of qualities and actions. Similarly quality is a generality by reason of its giving rise to a notion including all qualities such as colour etc., and it is an individuality, on account of its serving as the basis of a notion exclusive of substances and actions. In the same manner, 'action' is a generality by reason of its serving as the basis of a notion inclusive of all the several actions of 'throwing upwards' etc. and it is an individuality inasmuch as it is exclusive of qualities and actions. Such classes, however, as 'substance', 'quality' and 'action' include many individuals and as such they are primarily regarded as generalities, and it is only indirectly or secondarily that they are regarded as individualities, by reason of their serving to exclude their substrates from other similar generalities.

That these generalities belong to a category distinct from substance, quality and action, is proved by the fact of their having a character totally different from these latter. For this same reason too, they are eternal.

These again are different from one another, by reason of each of them residing in a different set of things, substances, qualities and actions, and also by reason of people having a distinct notion with regard to each of them.

Each of these is regarded as one in all its substrates, because

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12. PDS VII 154

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its character in all remains the same, and also because there are no marks of difference. Though generalities do not have their extension limited, yet they are regarded as extending over all their objectives; because of the definitely restricted character of the distinguishing features of the objects and also because of the fact of these objects having definitely distinct causes of their own. As generalities do not exist, either by conjunction or by inherence, in the intervals (of space between two individuals of the same class), they are not spoken of as existing (in these intervals).[13]

INDIVIDUALITY (Vaiśesha)

Individualities are the ultimate *i.e.* final specificatives or differentiatives of their substrates. They reside in such beginningless and indestructible, eternal substances, as the atoms, ākāśa, time, space, soul and mind, inhering in their entirety in each of these and serving as the basis of absolute differentiation or specification.[14]

The concept of 'vaiśesha', forms a distinguishing feature of the Vaiśeshika philosophy, from which the latter derives its name as well. Vaiśesha obviates the necessity of assuming a self-differentiating faculty for each individual substance by providing a common name for all such ultimate differentia.

INHERENCE (Samavāya)

Inherence is the relationship between things that are inseparably connected, and which stand to each other in relation of the container and contained. From it proceeds the notion that 'this subsists in this' as for example 'the cloth is in these threads', 'the mat is in these reeds'.

Inherence is not mere conjunction, because:

(1) The members of this relationship are inseparably connected.
(2) This relationship is not caused by the action of any of the

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13. PDS VIII 154, 155
14. PDS VIII 156

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members related.

(3) It is not found to end with disjunction of the members.

(4) It is found subsisting only between the container and the contained[15].

Such were the views of Kanāda and more particularly of Praśastapāda about the matter and its associated features.

Now let us see what were the views of ancient Indian systems about creation of matter and the universe.

CREATION OF MATTER ACCORDING TO SĀMKHYA SYSTEM

Sāmkhya system describes elaborately creation of matter and the universe. Expounder of this system was Kapila.

Let us first see who was Kapila and when and where did he live and in what circumstances he propounded his views.

KAPILA

Kapila is said to be the son of Vitātha and Devahuti, and a descendant of the great Brāhmana sage Manu, the law-giver. He was probably born at Pushkara, a sacred bathing place near modern Ajmer and he lived at Gangānagar.

A Jaina legend places him before the Buddha and Mahāvira. Bhagvadgitā mentions Kapila as a sage who had obtained perfection and liberation. Ramāyana refers to him as a great sage and a historic personage. Vyāsa, the author of the commentary on Yoga-sutra and Vāchaspati Miśra, author of a gloss on the commentary of Vyāsa, refer to a tradition according to which Kapila, the historic personage, was called Adividvān (the first of the knowers) and Bhagvan Parmarishi (the revered great sage). Bhāgavata Purāna mentions him as being the first in the line of perfected souls (siddhas), who had by spiritual enlightenment secured liberation. It describes Kapila as the son of sage Kardama

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15. PDS IX 157

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by Devahuti, daughter of Manu Svayāmbhu.

Kapila is said to have possessed miraculous powers and to have performed superhuman deeds. A mythical episode in Mahābhārata[16] describes that the sixty thousand sons of a chakravartin named Sagāra were riding as the armed guard of their father's sacrificial horse, while it wandered over the kingdoms of the different lands. Suddenly, to their profound distress, it vanished before their very eyes. They started digging the place where it had disappeared and ultimately found it in the under-world. Beside it was sitting a saint in deep meditation. Eager to capture their horse, they paid no respect to the saint, who was no other than the sage Kapila. Annoyed by their impertinence, he, with just a flash from his eyes, burnt them all to ashes.

The word Kapila is an epithet of the sun, whose power he was supposed to possess in abundance.

Judging from the above different sources, particularly Jaina and the Buddhist, it appears that Kapila lived before the sixth century B.C.

Later in his life, he was disgusted with the prevailing beliefs and practices of his times. So he thought out for himself and others a doctrine or system by which he hoped to solve the mystery connected with matter and spirit. He was held in high esteem by people in his own times and his superior knowledge and integrity was praised by even those who did not agree with his doctrines. A veil of mystery and myth, later on, gathered around his name and so much reverence was attached to him that he was sometimes called the divine Kapila, a son of Brahma, incarnation of Vishnu, a form of Agni etc.

The doctrine or system which he expounded is called Sāmkhya.

SĀMKHYA TEXTS

Our present knowledge of Sāmkhya is based on the texts of Sāmkhya Kārikā, Sāmkhya-sutras and their commentaries by

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16. M.B. 3. 107.

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different authors. Sāmkhya Kārikā is the oldest Sāmkhya text now available.

So far as the text of Sāmkhya-sūtras is concerned, it is not referred to by any writer till the fifteenth century A.D. Gunaratāna of the fourteenth century A.D., who mentioned various Sāmkhya texts, did not mention the sūtras and no other writer before him made any reference to it. It was only in the fifteenth century that Sāmkhya-sūtras were commented upon by Aniruddha. So it looks natural that Sāmkhya-sūtras text, as we know it now, was written after the fourteenth century.

But that does not mean that what it contains is only as old as the fourteenth century A.D. In fact, at the end of Sāmkhya Kārikā text, which was composed by Ishvāra Krishna in the middle of the fifth century A.D., it is said that it excludes the refutations of the doctrines of other people and the parables attached to the original Sāmkhya work, the Śastitantra-śastra. Sāmkhya-sūtras, however, contain these refutations and parables. From this, perhaps, we can suppose that Sāmkhya-sūtra text is the same as Śastitantra-śastra, except for its changed name.

While the above account tells only about the collected works of Sāmkhya system, some of the Sāmkhya concepts themselves are even older. They can be traced back to the Upanishads and even to the Rigveda[17] in their rudimentary form.

How this system came to be called as Sāmkhya is not known clearly. The word Sāmkhya means number and so according to certain people, this system was so named because it aimed at acquiring the knowledge of reality by enumeration of the ultimate objects of knowledge. It states the successive evolution of the prakriti, the first cosmic principle.

PRAKRITI AND GUNAS

According to Sāmkhya theory, the visible manifested universe evolved out of an invisible, unmanifested, formless, undifferen-

17. *Origin of Sāmkhya* (1953) by M.C. Pandya.

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tiated, infinite, indestructible primordial ground called prakriti which is eternal, without a beginning or an end. This prakriti is made up of three basic real entities called gunas which, in turn, are again indeterminate and incapable of independent existence, but they do possess certain characteristic properties. The first guna is called the matter (tamas) and it has the property of inertia. The second is the energy (rajas) and it has the property to do work or to overcome resistance. The third is essence (sattva) and it has the property to manifest something to senses. All these gunas exist in uniform diffusion and equilibrium in prakriti. Tendency of the energy to do work is counter-acted by inertia of the matter and so the unmanifested nature of prakriti is maintained.

DISTURBED PRAKRITI

Puruśa, the God, through its transcendental effect caused a disturbance in this state of equilibrium of prakriti and thus initiated the process of creation. One of the gunas, the energy, was disturbed first and then the others also began to vibrate. This produced a tremendous commotion in prakriti and led to an unequal collection of gunas, with relative preponderance of one or the other in different places. Thus commenced the formative combination among gunas, and this set into motion creation of the universe.

IMPERCEPTIBLE CREATION

In the first stage of creation, by the action of energy on matter, an absolutely inert, homogeneous and ubiquitous material was created, which was devoid of any physical or chemical property except mass; but even this was imperceptible. To this the name bhūtadi is given.

In the second stage, from bhūtadi appeared five different kinds of tanmātras, the infra-atomic particles charged with various kinds of potential energies. These resulted from the unequal aggregation of original mass units in different proportions with unequal distribution of the original energy (rajas). This energy upon the

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tanmātras, endowed upon them certain potential characters such as of sound, touch, colour, taste and smell; only one character being on one tanmātra. These characters were not manifested yet, as tanmātras were physically imperceptible.

GROSS OR PERCEPTIBLE CREATION

In the third stage, there occurred the formation of five different perceptible gross elements, collectively called as bhūtas. These are composed of different kinds of anus, which are the indivisible smallest particles of a thing, as for example are the smallest motes which are seen floating in the air in the path of a sun-beam. The gross elements and their anus are called ether (ākāśa), air (vāyu), fire (tejas), water (apa) and earth (kshiti).

The examples of the above different bhūtas are as follows:

Ether : This is ubiquitous.

Air : Familiar example is atmospheric air. (Water vapour is only water and smoke and fumes are the earth particles in gaseous medium.)

Fire : Pure example is lacking. Different examples of heat and energy are the mixed forms, as is fire, light and heat emitted by a burning log of wood. It is 'tejas' mixed with earth particles. The same is the case with the light of the sun and the stars, which was supposed to be produced by burning masses of viscous molten metals. Lightning also liberates a kind of 'tejas'. Heat in the animal body is derived from the break-up of the nutritive material. And lastly, there comes the peculiar form of 'tejas' the radiation energy, stored up in certain ores and rocks.

Water : Example is pure water, though various organic and inorganic constituents in it, make it a mixed stuff.

Earth : Majority of the elements belong to it.

'ANUS'

Different anus of the gross elements are themselves complex

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tanmātric structures and their formation has been worked out differently by different authors. In a general way, it can be stated as follows:

From the sound tanmātras, by their aggregation, is produced an anu of 'ether', which is mono-tanmātric and whose gross element is all-pervading and has the quality of sound. Touch tanmātras on combination with that of sound produce an anu of 'air' which is di-tanmātric and whose gross element forms a gaseous envelope and has the attributes of both sound and touch. Colour tanmātras on combination with that of sound and touch produce tri-tanmātric anu of 'fire', whose gross element causes huge flames and has the properties of sound, touch and colour. Taste tanmātras on combination with those of sound, touch and colour give rise to the production of tetra-tanmātric anu of 'water', whose gross element is the viscous fluid with the qualities of sound, touch, colour and taste. The smell tanmātras on combination with the previous four, give rise to penta-tanmātric anu of 'earth', whose gross element is the solid matter which has all the properties of sound, touch, colour, taste and smell. An anu of ether possess penetrability, of air impact or mechanical pressure, of fire radiant heat and light, of water viscous attraction and of earth cohesive attraction.

Vast variety of substances, all belonging to the same gross element, are the result of the differences in the attachments of various gunas and tanmātras in them. And this is how an infinite variety of the world objects result from infinitely varied combinations of the three basic gunas, according to the Sāmkhya system.

CONSERVATION OF MASS AND ENERGY

According to Sāmkhya, gunas are always uniting, separating and uniting again, so that the cosmic evolution is a two-fold process: creative as well as destructive. Though in combination, gunas form various objects, yet they themselves can neither be created nor destroyed. The totality of the matter as well as of the energy remains constant, if we take into account both the

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manifested and the unmanifested, the actual and the potential.

PROCESS OF EVOLUTION

In the process of creation of the universe, the successive changes do not occur from whole to parts or from parts to whole, but from a relatively less coherent, less determinate whole to a relatively more coherent, more determinate, more differentiated whole.

In the creative process, there is aggregation, unequal though, of mass and energy, with consequent transformation of energy, resulting in the creation of inorganic as well as organic matter. Successive steps of such a process may be described as: (1) unequal aggregation with storing up of energy in a certain collocation, under a state of arrest (*i.e.*, in a state of relatively stable equilibrium), (2) a stimulus removing the arrest and disturbing the equilibrium and (3) liberation of the energy, moving on to a fresh collocation, fresh aggregation, arrest and equilibrium. This process of creation thus moves on from equilibrium to equilibrium and the result is the development of a coherent, determinate, heterogeneous whole in what is essentially an incoherent indeterminate homogeneous whole[18].

PROCESS OF DISSOLUTION

An important aspect of this evolutionary process is that unequal aggregations are unstable. There is a constant tendency in things to go back to the original stable equilibrum, the state of uniform equal diffusion of gunas. Collocations of mass, energy and essence are thus always breaking up, and the energy as well as the mass, however slowly, however imperceptibly, are being dissipated *i.e.*, dissolved into the original formless prakriti, a state of permanent equilibrium and arrest from which there is, and can be, no return, except under the transcendental influence of the Absolute at the

18. Seal, B.N. : *Positive Sciences of the Hindus*, p. 22.

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commencement of a new creative cycle.[19]

SĀMKHYA AND VAIŚESHIKA COMPARED

According to Sāmkhya, properties of a thing are due to the energies that are manifested in a particular collocation of the three gunas *i.e.*, the mass, energy and essence. The two substances of the same bhūta class differ from one another because of the different groupings or the quanta of tanmātras in their infra-atomic structure.

In the Vaiśeshika (and also in the Nyāya), on the other hand, atoms of the same bhūta class are alike in themselves and homogeneous. The variety of substances comprehended under the same bhūta is ascribed merely to the different arrangements or groupings of the atoms and not to their components.

SĀMKHYA COMPARED WITH MODERN THEORIES

How does this ancient Indian theory of the creation of matter and of the universe compare with our modern scientific knowledge?

Modern scientists, in fact, look thoroughly puzzled about it and they have no single answer, as one can witness from some of the following excerpts.

Professor Hoyle says: "From time to time, people ask where the created material comes from. Well, it does not come from anywhere; material simply appears. At one time the various items composing the material do not exist and at a later time they do. This may seem a very strange idea," he says, "and I agree it is, but in science it does not matter how strange an idea may seem, so long as it works, that is to say, so long as the idea can be expressed in a precise form and so long as its consequences are found to be in agreement with observation." He concludes, "In any case, the whole idea of creation is queer."

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19. *Ibid.*

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Professor Bondi says: "...It should be clearly understood that the creation is not out of radiation but out of nothing."

The former Astronomer-Royal Sir Harold Spencer Jones says: "Questions that are often asked are: 'What is the matter created out of and what form does it take'? It is created out of nothing. It must be supposed that there is eternally a true creation going on as a continuous process."

Professor J.R. Oppenheimer, on the other hand, says in his Reith lectures: "What physicists call vaguely and rather helplessly, 'the new particles' are the greatest puzzle in today's physics, but this answer or absence of any answer cannot possibly be allowed to stand as part of any picture of universe established by physics, for the idea of creation out of nothing is not science at all; it is mere magic." "An ether hypothesis", he says, "if accepted, would regard the production of new particles, as also, of new radiations or new lines of force, as part of the normal functioning of cosmos." He continues further, "The answer to the question, 'where do the particles come from', would be that they come out of the universal primordial matrix of quiescent energy."

This, 'universal primordial matrix of quiescent energy' of the modern eminent scientist is 'prakriti' of the ancient Indian philosopher-scientist Kapila. It is worth noting here that both suggest this answer by metaphysical contemplations alone.

This is yet another example which shows that where laboratory experiments cannot give an answer, metaphysics provides an hypothesis to work upon. The two together help each other and need each other.

MATTER ACCORDING TO JAINAS

Pudgala is the Jaina word for matter, and it exists in two forms: anu and aggregate of the anus, skandha.

Anu has no parts, no beginning, middle or end. It is not only infinitesimal but also eternal and ultimate. Each anu possesses an imperceptible potential such as of taste, smell and colour, and also has two imperceptible tactile qualities *i.e.*, of the roughness-

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smoothness, dryness-moistness, hardness-softness, heaviness-lightness, heat-cold.

A skandha can vary from a binary aggregate to an infinitum; a binary being an aggregate of two anus, a tertiary of three, formed by addition of one more anu to a binary and so on. A skandha may possess physical, perceptible characteristics of sound, dimension, shape and configuration, divisibility, opacity, radiant heat and light.

From the above, we see that pudgala in its original state corresponds to bhūtadi of the Sāmkhya, being homogeneous and indeterminate. From it, determinate and discrete particles (anus) arise as a result of evolution.

MATTER ACCORDING TO BUDDHISTS

According to the Buddhists, matter consists of four infra-atomic entities, namely of colour, taste, smell and touch. Aggregation of these four gives rise to atoms (anus) of air (vāyu), energy (tejas), water (apa) and earth (kshiti) respectively.

Air (vāyu) atoms are touch sensible and have impact or pressure as their characteristic property.

Energy (tejas) atoms are colour and touch sensible and have heat as their characteristic property.

Water (apa) atoms are taste, colour and touch sensible and have fluidity as their characteristic property.

Earth (kshiti) atoms are smell, taste, colour and touch sensible and have dryness or roughness as the characteristic property.

These four entities give rise to various organic and inorganic substances.

MATTER ACCORDING TO VEDANTISTS

According to Vedāntists, while the world evolves out of Māyā, Māyā itself originates out of Brāhma, the Absolute Reality. Māyā is the material cause of the world. Through Māyā is produced ākāśa which is one, infinite, ubiquitous, imponderable,

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inert and all pervasive. From ākāśa evolves out vāyu which is infra-atomic, imperceptible gaseous matter; from vāyu comes out tejas which is infra-atomic radiant matter; from tejas evolves out apa which is infra-atomic viscous matter and from apa evolves out kshiti, the infra-atomic hard matter. This is how, in the ascending complex order, the evolution of these infra-atomic imperceptible matter (sūkśma-bhūta) occurs. Ākāśa sūkśama-bhūta has the capacity of sound, vāyu of mechanical energy *i.e.*, of impact and pressure, tejas of heat and light, apa of taste and kshiti of smell.

These five sūkśma-bhūtas combine in different ways, called quintuplication (panchikarāna), to give rise to the corresponding five gross forms of matter (mahābhūtas). All the five sūkśma-bhūtas are present as ingredients in each mahābhūta, though they are in different proportions in each, as for example, earth mahā-bhūta is composed of four parts of earth sūkśma-bhūta and one part each of the other forms of sūkśma-bhūta. Similarly vāyu mahābhūta is composed of four parts of vāyu sūkśma-bhūta and one part each of the others and so on.

Mahābhūta ākāśa has perceptible quality of sound, vāyu of sound and mechanical energy, tejas of sound, mechanical energy and heat-light, apa in addition to the above has qualities of taste, and kshiti of all others plus smell.

Different mahābhūtas are also characterized by their typical sounds, as for example, ākāśa by the echo, the hollow booming sound ; vāyu by the sibilent hissing sound (imitative symbol 'visi') ; tejas by a puffing roaring sound (imitative symbol bhugu-bhugu), apa by a liquid sound (imitative symbol culu culu, gurgle-gurgle, plash plash, glut-glut) and kshiti by a splitting or rattling sound, a crack or thud (imitative symbol 'kad-kad').

From these mahābhūtas are produced different substances by evolutionary process called 'parināma'. This may occur by a spontaneous process without external influence or be due to combination with other substances producing compounds with like or unlike properties.

Vedāntists, as we have seen, do not recognise the atomic struc-

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ture of matter. According to them, the sūkśma-bhūtas are homogeneous and continuous matter, while the mahābhūtas are composite and continuous. The Vedāntists speak of anu (pramānu) only as the smallest conceivable quantum or measure of matter.

Now that we have seen the different ancient Indian views about matter and its creation, let us see how did other people in other lands, in ancient times, thought about it. Greek thinkers put forward a host of interesting views on this subject. Their study and comparison with the different Indian views forms an interesting subject.

ANCIENT GREEK VIEWS

Thales: He, the first of the Greek (Milesian) thinkers, thought of the perceptible world as neither stable nor permanent. Everything, according to him, in the universe was destructible. The basic material out of which all else was created was water. Water not only created the universe but even engulfed it on all sides: "The earth is borne on water, the universe is supported by water and the fire of the sun and the stars, indeed, the entire world is surrounded by exhalations of waters."

Anaximander: He held that the material cause and the first element of all things was the 'apeiron'—a sort of distant relation of air—which is eternal and surrounds the entire world. Apeiron contained all the elements in undifferentiated profusion and was the cause of all things. Things did not originate out of the modifications of matter but by the separation of the opposite properties of this primordial substance.

Anaximenes: He held that air (like water of Thales) was the universal principle and all material things were generated out of it by rarefaction or condensation. "Expansion and condensation cause air to assume its diverse forms—when it condenses it produces first water, then earth and at the highest degree of condensation it produces stones."

Heraclitos: He claimed that "fire governs the universe; all things are changed by fire and fire by all things". Fire engendered

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air, water and the earth. Elements could be transformed, one into the other; transformation, according to him, being the universal law of instability. Every thing in the universe was being transformed constantly.

Xenophanes: His universal principle filled the universe and was one with God. This 'one' principle contained the manifold and transcended its oppositions. Hence it explained immutability as well as the fleeting nature of things.

Parmenides: He furthered Xenophanes' monistic concept by postulating an all-pervading reality—a Being, behind all phenomena; instead of a primordial element which engendered all substances by transformation etc.

Pythagoreans: They were the first to abandon the monistic nature of things and they propounded dualistic philosophy. They recognized ten oppositions in five pairs, *viz.*, limited-unlimited, odd-even, one-multiple, straight-curved, square-polygonal They looked upon numbers as the real constituent elements of matter.

Empedocles: He talked of the four primordial elements: water, air, fire and earth. These were the 'roots' of all things in the universe and they were indivisible, immutable and eternal. All phenomena in the universe could be explained by their combination which, according to him, took place under the action of two opposite forces, love and hate. During the reign of hate the elements are separated, from hate to love the elements draw together and begin to combine, during the reign of love harmony is establised to produce a perfect world, a subsequent return to hate causes the beginning of disintegration.

Anaxagoros: He postulated existence of a sort of 'apeiron' (like that of Anaximander), a primordial entity which was upset by 'nous' (mind or breath) and thus appeared the organized universe.

He believed in infinite divisibility of matter and its indestructibility: "There is no last degree of smallness, for there is always something smaller. Nothing is born or dies, but existing things combine or separate." There was infinite diversity of elements. A material substance was not composed of identical elements. It contained every possible element, though it is the predominance of

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one which accounts for its apparent qualities.

Leucippos and Democritus: Their universe consisted of atoms, which were the ultimate indivisible particles. These atoms were said to be eternal, immutable, imperceptible, infinite in number, indestructible, solid, impenetrable. They were of infinite variety. Though all of one substance, they differed in form, dimension, position and mutual arrangements.

They were in motion within the infinite void so that they were in incessant flux producing different combinations and the substances of the universe. "We say hot, we say cold, we say sweet, we say bittter, we say colour, but nothing exists save only atoms and the void."

VAIŚESHIKA VERSUS DEMOCRITUS' ATOMS

We have seen that the main features of the atomic views of the Vaiśeshika are the four elements namely earth, water, fire and air. The atoms of one element are different from those of the other three. Each of the four different classes of atoms has a specific or distinct quality by which it can be distinguished. All the atoms, however, are spherical, indestructible, indivisible and have the minutest dimension (parimandalya). Atoms of Democritus, on the other hand, are all of one similar substance; only they differ as regards form, dimension, position etc. Thus the atoms of the Vaiśeshika are qualitatively different in contra-distinction to the quantitatively different atoms of Democritus.

Both Democritus and Vaiśeshika, however, agree on one thing that the atoms are in eternal motion. According to Democritus, the motion of atoms is a specific characteristic of atomicity itself and the motion occurs in the great void. The Vaiśeshika, however, has a different explanation to offer for the first cause of the motion of atoms *i.e.*, the Divine Will.

Plato: To him (428 or 427 to 348 B.C.), the basic elements of matter were the five regular polyhedra (the Platonic bodies). Four out of these five corresponded to the four elements of Empedocles. Tetrahedron represented fire, octahedron the air, icosahe-

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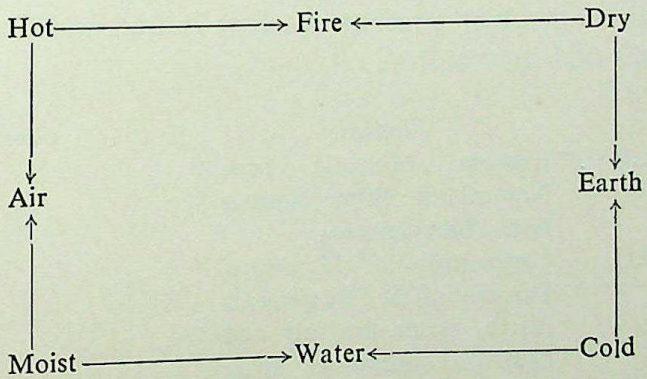
dron water and cube the earth. Dodecahedron, the fifth regular polyhedra, "God used it in his final design for the universe as a whole."

Plato, as we see, described the outer form rather than the essential contents of the materials.

Aristotle: He (384 or 383 to 322 B.C.) described the four Empedoclean elements of earth, water, air and fire, not as original elements but as different aspects of a primary matter or protyle. According to him, the basis of the material world is the prime matter which is of potential existence only unless it is impressed with 'forms'—forms being the fundamental properties or primary qualities of a body. These qualities, he said, are four in number, generally expressed in two pairs of contrary characters, *viz.*, hot and cold, dry and moist. It is the presence of one of these pairs which characterizes each of the four elements as shown in the diagram below:



In theory, the four qualities ought to combine into six pairs, but two do not exist in nature, namely cold-hot and dry-moist, since contradictory qualities do not combine. These four elements, namely, earth, air, water and fire, then combine to form all the substances of the universe. They can also produce one from the other by the addition and subtraction of appropriate qualities.

Aristotle also postulated a fifth element, the ether, representing empty space.

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We can summarize different views of the Greek thinkers about matter and its creation as follows[20]:

(1) An infinite multiplicity of substances from the beginning of time (Anaximander, Anaxagoras).

(2) A limited number of elementary substances which combined to produce all known substances in nature (Empedocles).

(3) A single primordial substance (water, air or fire) capable of transformation into all other substances by condensation, rarefaction etc. (Thales, Anaximenes, Heraclitos).

(4) A single substance, without qualities but divided into discrete particles, the basic elements, which combined to form all other substances (Leucippos, Democritus).

(5) That all things are the products of whole numbers, was a doctrine which came before the atomic hypothesis and was its forerunner inasmuch as it implied that matter was discontinuous and that substances combined according to whole numbers (Pythagoras).

The following table[21] presents ancient Indian and Greek views about matter and its creation.

Period	*Indian*	*Greek*
C. 2000-1500 B.C.	Rigveda. Monistic ideas, Natural law : Primeval water as the first element	—
C. 900-600 B.C.	Upanishadic Literature. Doctrine of the Five elements (earth, water, fire, air and ākāśa), concepts of space and time, Pre-classical Sāmkhya. Evolutionary concepts of matter. Vaiśeshika school : Substance, qualities and motion, atomism; epistemological roots.	—

20. Teton, R. : *History of Science : Ancient and Medieval.* Basic Books, Inc. New York (1963), p. 197.

21. Subbarayappa, B.V. : Ind. J. His. Sc. *Estimate of Vaiśeshika Sūtra in History of Science*, May 1967, p. 29-30.

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Period	*Indian*	*Greek*
C. 600-300 B.C.	Buddhism and Jainism. New concepts of matter and motion; atomism finding new adherents. Nyāya-sutras. Integrated views of substance including space, time, self and mind clothed with theories of causation.	Beginnings of Pre-Socratic philosophers' speculations. Doctrine of single element (Thales, Anaximenes, Heraclitos), philosophy of numbers (Pythagoreans), atomism (Democritus) doctrine of four elements (Empedocles). Plato and Aristotle. Ideas as norms (Plato); doctrine of five elements; matter as potential and form as actual; concept of unmoved mover ; theories of causation (Aristotle).

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8

Physical and Chemical Action

PHYSICAL ACTION

According to the Vaiśeshika system, atoms (pramānus) possess an intrinsic vibratory or rotatory motion (parispānda) so that one atom combines with another under an inherent impulse to form a binary molecule (dvyanuka). Larger aggregations can be formed in three different ways: (1) by combination of these binary molecules among themselves in groups of three, four, five etc., (2) by combination of the atoms themselves in pairs, triads or tetrads directly or (3) by successive addition of one atom to each preceding aggregate.

The above mechanisms of physical coherence or combination, apply to all the four different types of atoms, namely, of earth, water, air and fire.

In such aggregates or combinations, if the two atoms forming a binary belong to the same class, the qualities produced in the binary are homogeneous and correspond to the original quality of the atoms. In such a situation, the diverse variety of the substances produced in the same class of atoms is due to the differences in the number and configuration of the atoms constituting the aggregate. If, on the other hand, the two constituents of a binary belong to different classes, the resulting binary does not possess any of the specific qualities of the constituents.

A classification, based on the above two types of combinations and the aggregates thus produced, may be stated as follows.

Mono-bhautic Aggregates: These are formed by the union of homogeneous atoms, even of different substances but belonging to the same bhuta class.

Hetero-bhautic Aggregates: These may be bi- or poly-bhautic

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and are formed by the union of heterogeneous atoms of substances belonging to different bhuta classes.

Vaiśeshika system gives even further intricate details of such combinations.

CHEMICAL ACTION (Pāka)

Pāka of the ancient Hindu scientists is a chemical action. It is, however, limited in its scope and has been explained in its own characteristic fashion when compared with the meaning of chemical action that we understand now. Herein conjunction of the fiery (tejas) with the earthly atoms takes place in such a way that the previous colour and other qualities of the earthly atoms are destroyed and in their place another colour and other qualities are produced. The resulting product of such a conjunction depends upon the material as well as the processes of this conjunction. A case in point is the ripening of a mango when it is kept under a heap of straw. Owing to fiery conjunction, its previous green colour may be destroyed and replaced by a yellow one; or the colour may remain the same and yet the taste may change or the consistency or the smell or a combination of some of these or all these qualities at one time or different times may appear, depending upon the process of conjunction.

Another example in a similar fashion is baking of a pottery object, by which its colour and consistency change irreversibly.

Process of Chemical Action (Pāka): This has been explained in a variety of ways.

According to Vaiśeshika system, for this action to take place, the object has first to be reduced to its pramānu state, as it is there that the action takes place. The old structure of the object is first destroyed before a new one can be produced. This view is labelled as Pilupākavāda.

The other view is that of Nyāya system and its followers. It says that it is not essential for the object to be reduced to its original constituent atomic stage and that the chemical action or fiery (tejas) conjunction can take place in composite structure as

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such also. This view is called Pitharapākavāda.

Stages: These have been explained differently by different Vaiśeshika authors. Chemical action has been shown to occur in nine, ten or eleven moments, parts or stages, depending upon the difference of opinion about the split-up of different stages (Vibhāgaja-vibhāga). Following is the process involving nine moments only.

First of all, a sort of motion is produced in the atoms of the binary by impulsion or forcible contact caused by the tejas. By that motion, disjunction between the two atoms producing the binary takes place, followed by destruction producing the substance called binary. This means (1) the destruction of the binary followed by (2) destruction of the blue colour etc. inherent in the atoms. Then comes (3) production of the red colour etc. in that very atom, after which (4) the motion favourable to the production of the substance is produced in the atoms which causes (5) disjunction of the atoms from the ākāśa etc. Then follows (6) destruction of previous conjunction leading to (7) conjunction between the two atoms producing the binary. Then comes (8) the production of the binary which then causes (9) production of the colour etc. in the binary. Thus beginning from the destruction of the binary upto the production of the red colour etc. in it, there are nine moments or stages.

The above process has also been split up further in ten or even eleven moments and described as such by different authors.

On the other hand, if some of the stages or moments described above are explained to have occurred simultaneously, then, the whole process of chemical action can be described in eight, seven, four, three or even two moments.

While the above are the views of the Vaiśeshikas, Nyāyas do not agree with them.

Chemical Action and Heat: In many ancient Indian philosophical works, particularly of the Vaiśeshika and the Nyāya systems, a close association of chemical change with heat has been recognized.

According to Vatsyāyana (first century A.D.), chemical changes

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may occur either by the application of external heat or may result from the operation of internal heat. When the fuel undergoes change by combustion, the heat evolved is believed to have existed in a latent form in the fuel before. Udayana in his Kiranāvali considers solar heat as the ultimate source of all the heat required for chemical changes occurring on this earth. This invisible solar heat was also believed to be responsible for change of colour in the grass, for the ripening of the mangoes in which their colour, smell and taste changes, for the rusting of metals (combination with the solar heat --suryapāka) and for conversion of food into blood. All these are instances of chemical transformation.[1]

Ancient Hindus considered heat and light rays as consisting of infinitely small particles radiating in straight lines in all directions with inconceivably high velocity and with a sort of conical dispersion. These on striking the atoms may break up their grouping, transform their physico-chemical character and bring about chemical changes.[2]

Importance of Chemical Action: If there were no such chemical actions, according to Udayana, there would have been no difference between the various kinds of touch, colour and smell. Thus there would have been no difference in the pain felt on touching an irritating herb, bite of a snake, scorpion or an insect. Also there would not have been the cessation of pain at the curative touch of some particular stone or some particular herb (snake-bite curing).

Again, it is only due to the chemical action that when a particular seed is reduced to its atoms, the different objects are produced out of those atoms qualified by the peculiarity formed by the chemical action (pākaja viśeshaviśiśta) in spite of the fact that there are no subordinate generalities (jātis) which could have helped determination of the difference in the products. As for instance, the seed of paddy is different from that of barley, the seed (cause) of man is different from that of monkey, the cow-milk is different from that of the she-buffalo. This is on account

1. Ray P. : Ind. J. His. Sc. May, 1966, p. 10.
2. Jayanta's *Nyayamanjari*, Eleventh Century A.D.

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of the difference of the respective generalities (jātis) belonging to them; but their respective atoms from which all these originate are differentiated by the chemical action alone. In other words, at the earliest stage, objects are differentiated mutually by chemical action alone, while at the later stages they are differentiated by the respective generalities (jātis) also.[3]

JAINA CONCEPTS

It is interesting to note that the Jaina concepts about matter and chemical action in it, are different in many ways. Tattvārthadhigāma of Umāsvāti, of the first or second century A.D., gives a detailed description of the atomic concept of matter and processes of combination in that. According to it, for chemical combination to take place between the atoms, they should ordinarily possess opposing qualities, as for example, roughness and smoothness, dryness and moistness. If, however, these opposing qualities are present but are weak, then either the chemical combination will not take place or it will be very feeble.

On the other hand, if the strength or intensity of the qualities of the two atoms differs widely, even though these qualities and atoms are similar, yet again a chemical combination in them will take place.

According to Jainas, a chemical combination among atoms leads to some change in their qualities.

VEDANTIST CONCEPTS

Chemical action such as fermentation of rice and molasses and subsequent production of alcohol in it, according to Vedāntists, is due to evolution of a latent energy already present in the mixture. Different elements (bhutas) combine with each other freely to produce different substances, an example of which is the animal body, a compound of all the bhutas.

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3. Ray P. : Ind. H. His. Sc. May 1966, p. 10.

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ANCIENT GREEK CONCEPT

After having seen different ancient Indian concepts about physical and chemical action, let us have a look at ancient Greek concept about the same.

Aristotle described the following three kinds of combinations (1) Synthesis which is simple mechanical mixture, (2) Mixis and (3) Krasis which are equivalent to chemical combination and solution. All the substances in the world, according to him, were produced by these combinations.

MOTION

The word used for motion, in ancient Indian terminology, is 'karma', literally meaning action.

Of all the old Hindu systems, it is only Vaiśeshika which deals with this subject adequately. In fact, it recognized motion as one of the six categories. Praśastapāda in the fifth century A.D., dealt with it thoroughly in his Padārtha dharma samgraha, a commentary or rather a revised edition of the Vaiśeshika-sutras. In later times, Śridhāra, Vyomāchārya and others tried to explain what Praśastapāda had written. Our knowledge of motion, as dealt here, is based essentially on Padārtha dharma samgraha of Praśastapāda.

TYPES OF MOTION

There are five types of motion. They are:

"Throwing upwards, throwing downwards, contracting, expanding and going. 'Going' includes all such actions as gyrating, evacuating, quivering, flowing upwards, transverse falling, falling downwards, rising and the like, as these are only particular forms of 'going' and not distinct classes by themselves."[4]

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4. Padārtha dharma samgraha (PDS). Eng. trans. and commentary by Jha., G.N. II. 1.6.

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CHARACTERISTICS OF MOTION

1. It belongs to a single substance (at a time).
2. It is momentary.
3. It resides only in corporeal substances.
4. It is without qualities.
5. It is produced by gravity, fluidity, effort and conjunction.
6. Two motions are counter-acted by conjunctions produced by themselves.
7. A motion is an independent cause of conjunctions and disjunctions.
8. It serves only as non-material cause.
9. It is productive of effects existing in its own substrate, as well as in the substrates of others.
10. It never produces effects of the same kind as itself.
11. It is not productive of substance and belongs to distinct well-defined class.
12. The distinctive features of each of the five kinds of actions consist in the direction in which its effect is produced.[5]

INDIVIDUAL MOTIONS

Throwing Upwards (*Utksepana*): Throwing upwards is that which brings about the conjunction of the parts of the body and things in contact with these parts, with points of space above them and also the disjunctions of these from those below them. This action is produced by gravity, effort and conjunctions.[6]

Opposite of this is throwing downwards (avaksepana).

Contraction (*Akuncana*): It is that by which a straight object becomes curved by reason of its particles at one end being disjoined from their original position and coming in contact with the points of space occupied by the particles at the other end.[7]

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5. PDS XI 138.
6. PDS XI 139.
7. PDS XI 141.

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Expansion (*Prasārana*): It is that by which the object becomes straightened by reason of the bringing about of conjunction and disjunction in directions opposed to the aforesaid.[8]

Going (*Gamāna*): It is that which brings about conjunctions and disjunctions with points of space in diverse directions.[9]

CAUSES OF MOTION

According to Praśastapāda, following are the causes of motion:

1. Gravity.
2. Fluidity.
3. Volitional Effort.
4. Conjunction. Impact (abhighāta) and impelling push (nodāna) are the special forms of conjunction.
5. Impetus (samskāra).
6. Unseen causes (adriśta)

1. *Gravity:* It is the cause of the falling motion of the bodies and rests with water and earth. It is imperceptible by the senses and can be inferred only from the act of falling. Gravity is countered by conjunction, volitional effort and impetus. Thus a body can be prevented from falling in three circumstances: (1) when it is in contact with something else and is unable to separate from it, (2) when it is held by volition, (3) when it possesses impetus.

2. *Fluidity:* It is the cause of flowing motion exhibited by all fluid or liquid substances.

3. *Impact or Striking* (*Abhighāta*): It is produced as a result of contact of a body possessing impressed motion (vega), provided such a contact is instantly broken. An example of this is striking of a ball on a hard surface when it again gets into motion instantaneously.

4. *Impelling push* (*Nodāna*): If in the above the contact continues, the result is impelling push or continued pressure (nodāna). In impelling push (nodāna), the conjunction brought

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8. PDS XI 142.
9. PDS XI 143.

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about by gravity, fluidity, speed, volitional effort between the impeller and the impelled continues and is not followed by disjunction. Gradual sinking of a piece of stone in mire or pushing of the javelin with the hand in the initial stages of throwing, are examples of impelling push (nodāna).

5. *Unseen (Adriśta) causes:* They include unknown or unexplained causes of motion, as for example, the first motion in atoms at the beginning of creation, upward motion of fiery particles, movement of iron towards magnet, ascending of liquids in the insides of plants etc.

6. *Impetus (Vega):* Pressure, impact or other force which produces the first motion, sometimes produces through that motion a persistent tendency to motion, which then becomes the cause of the continued motion in the direction of the initial motion, even while the initial force ceases to act. This persistent tendency to motion has been called by the Vaiśeshikas, vega (impetus), a form of samskāra. Impetus (vega) is thus not only caused by motion but is a cause of motion also. A motion is persistent only when it possesses sufficient impetus (vega), otherwise, it is only short-lived. Not all motions possess impetus.

This impetus which arises out of and is associated with motion must then have some cause. While Praśastapāda vaguely mentions 'efficient cause' for it, it is only the later writers[10] who indicate impelling push (abhighāta) and impact (nodāna) as its causes.

In the illustrative example given by Praśastapāda of the causes of various motions when a shot is thrown by a hand, there is a suggestion that the distance over which a shot can travel under the influence of impetus (samskāra) depends upon the intensity of the effort put in by the thrower. This shows his grasp of the concept of a direct proportion between impelling push and impact and the vega produced thereby. Secondly, he clearly indicates the direction which impetus takes by saying that "vega is the cause of uninterrupted continuity of motion in a fixed direction," *i.e.*, in the direction in which it is being applied by the force. Thirdly, he

10. Vyomāchārya and Śridhāra.

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says that this impetus (vega) is countered by the contact with special tangible substances capable of offering resistance.

Such a conception of impetus (vega) by the Vaiśeshikas is a near approach to our modern conception of momentum.[11]

ILLUSTRATIVE EXAMPLES

To illustrate different motions and to show how a motion is produced by a combination of causes, Praśastapāda explains the following motions of common occurrence.

1. *Working of Pestle and Mortar (Taking-up and throwing-down a stick):*[12] After taking the stick in his hand, the man has the desire to throw it up by means of the hand. There follows an effort (volition) on his part, and when this effort influences contact of the soul with the hand, there appears in the hand an action of being thrown up or raised; and simultaneously with this there arises a like action in the stick, following from contact of the hand and the stick, as influenced by the said effort.

Then again, when the stick has been thrown up to a certain point, the desire for throwing it up disappears, and there appears a desire to bring it down. This is followed by an effort which affecting the aforesaid contact brings about simultaneous bringing down of the hand and the stick, the last of the series of downward motions of the stick brings about a particular kind of conjunction called thumping or striking (abhighāta) of the stick with the mortar. This conjunction influenced by the momentum set up in the stick produces in this latter an 'unconscious' action in the shape of an upward rebound.

The last action and the aforesaid thumping, set up in the stick a certain faculty or momentum, and by the help of this faculty, contact of the hand with the stick produces in the hand also an 'unconscious' action in the form of the upward rebound. Even

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11. Sen, S.N. : Ind. J. His. Sc., *The Impetus Theory of the Vaiśeshikas*, May, 1966.

12. PDS XI 145.

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though the previous faculty (of the stick) is destroyed (by the thumping) yet the contact of the stick and the mortar, being capable of producing a forcible action, becomes capable of producing another faculty, by reason of the peculiar character of the contact.

Or it may be that the previous faculty itself being forcible, continues to exist, not being wholly destroyed by the thumping. And hence when an object has a faculty present in it already, there is no other faculty produced in the same, and so at the time when the thumping aided by the faculty produces in the stick the 'unconscious' action of the upward rebound, that same faculty helps the hand-stick contact to produce in the hand also the 'unconscious' action of the upward rebound.

When the mortar thrown by the hand rebounds after striking the pestle, the two causes of motion working here are the impact with the impetus.

2. *Throwing a Shot by the Hand:* There arises in man a desire to take hold of the mace by his hand and to hurl it. This is followed by an effort on his part and by the instrumentality of this effort, from the aforesaid two contacts, there arises simultaneously in the hand and in the mace, the action of 'contraction' or 'drawing'.

When the arm is extended again, the effort put forth towards the contraction ceases. After this, there arises in man a desire to throw the mace either horizontally or vertically to a distance great or small. This is followed by an effort and in accordance with this effort, is brought about the hand-mace contact which is called impulsion (nodāna), and this brings an action in the mace in the form of impulsion.

This impulsion produces in the mace a certain impetus (samskāra) and from these two, impulsion and impetus, a number of actions go on being produced until the mace is released from the hand. When this release makes the impulsion cease, the impetus continues to produce a number of actions tending either upward or aslant, near or far, according to the nature of the effort put forth by the person until the mace falls on the

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ground.[13]

Thus we see that throwing a shot by the hand involves the use of two different causes of motion, namely, of impulsion and impetus.

3. *Throwing an Arrow with a Bow:* The man takes up the bow with his left hand; then taking with his right hand the arrow and applying it to the string of the bow, he catches with his fingers the arrow alongwith the string. Then there arises in his mind a desire to draw the bow along with the string and the arrow. This is followed by an effort on his part and by the instrumentality of his effort, the hand-soul contact brings about in the hand the action of 'drawing'. At the same time, by the instrumentality of the same effort, the hand-arrow-string contact brings about an action in the string and also in the arrow. Simultaneously with this again, by the instrumentality of the hand-arrow-string contact as qualified by the said effort, contact of the string with the two ends of the bow, produces two actions in the two ends of the bow. Thus the bow being drawn as far as the ear, there appears in the mind of the person the idea that it cannot be drawn further, and this idea destroys the effort that had been put forth for the purpose of drawing the bow. Then there follows a desire for releasing the bow. This is followed by another effort on the part of the person, and by the instrumentality of this effort the soul-finger contact produces an action in the finger which brings about a disjunction of the string from the fingers. From this disjunction follows destruction of their contact, this contact having been destroyed, as there is no longer any obstruction to the operation of the elasticity of the bow, which now makes the circular bow revert to its original condition, and by the instrumentality of this force of elasticity, the bow string contact produces an action in the string and in the arrow. This action, by the instrumentality of its own cause, produces an impetus (samskāra) in the string; and by the instrumentality of this impetus, the arrow-string contact brings about an 'impulsion';

13. PDS XI 146.

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and thence the first action in the arrow, by the instrumentality of this impulsion, produces an impetus or force in the arrow. From this faculty, as helped by the impulsion, follows a series of motions which continue to appear until the arrow becomes disjoined from the bow. This disjunction having put a stop to the impulsion, the further series of actions (motions) of the arrow is due to the impetus imparted to it, and these motions continue until the arrow falls on the ground.[14]

In short, the first motion is due to impulsion and this results in an impetus being produced. The subsequent motions are produced by the impulsion acting concurrently with the impetus.

4. *Revolution of the Potter's Wheel:* In the case of such things as the potter's wheel (and the like), we find that the component particles undergoing a series of conjunctions and disjunctions with definite points of space on its sides, there is produced in the wheel as a whole, an action, produced by impetus (samskāra), by the instrumentality of conjunctions and disjunctions with points of space not restricted to a single space. This action is what is called revolving (brahmana), a particular form of 'going' motion.[15]

Analysis and combination of forces here is the same as that observed in the above case of the bow and the arrow.

5. *Action of Breathing:* Action is produced in the air called breath, by the soul-air contact, by the instrumentality of efforts originating from desires and aversions. This we learn by the fact that the 'breathing' of the waking man follows the bent of his desire, and that in the sleeping man is due to the instrumentality of the effort involved in the mere act of living.[16]

6. *Flowing of Water from a River by a Breach in its Embankment:* (Before the water flows) its inherent fluidity is kept in check by its contact all round with the high earth-banks. The fluidity of its component particles that are in direct touch (with the banks) is kept in check by the same contact, by reason

14. PDS XI 147.
15. PDS XI 151.
16. PDS XI 152.

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of its inhering in the same substrate (with this contact); and the fluidity of the other particles is checked by the 'contact of the conjoined'. When, however, there is the slightest breach in the surrounding embankment, then though the fluidity of the whole volume of water is still kept in check on all sides and hence it does not become active (begin to flow) yet the fluidity of the particle in direct contact with the opening becomes active, and this activity is transferred gradually to the fluidity of the other particles also. As the obstruction goes on disappearing, there is a gradual moving of these particles in conjunction with one another, and the original volume of water having been destroyed (by the destruction of its cohesive conjunction), the water particles adhering to one another produce another, an elongated substance (and elongated volume of water); and in this fresh substance the quality of fluidity is produced in accordance with the similar quality in its originative component particles. And thus when these originative component particles continue to move in conjunction, there is produced a like action in the composite wholes also; and to this action we give the name of flowing, a form of 'going' motion.[17]

Now that we have seen what the ancient Indians thought about motion, its types, causes etc., let us see what were the concepts of the ancient Greeks on similar matters. And as it was Aristotle only who delved in these problems and formulated his views on them, we will see what he said.

ARISTOTELEAN CONCEPT OF MOTION

Aristotle said that the four elements *viz.*, the earth, fire, water and air had certain specific natural motions inherent in them. Of the element earth the natural motion was downwards (towards the centre), of fire upwards (away from the centre), of water downwards (except central region) and of air upwards (except in the region of fire). Thus, according to him, if a substance is trans-

17. PDS XI 150.

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formed into fire by combustion, the flame rises because it tends to rejoin the fire. Similarly every solid tends to fall down towards the earth from which it has sprung. Air and water find their natural levels in the same way.

Motions other than 'natural' ones of an object were considered by him as 'unnatural' or 'forced'. He said that without an external force, all bodies would remain at rest. These external forces, he said, originate in the outermost spheres of the heavens and are communicated by the successive layers of spheres to the sub-lunary world.

The fifth element of the universe, according to Aristotle, is ether, which resides above the level of the moon in the celestial regions and whose natural motion is circular. He postulated this, as it is only the circular motion which is regular and has no beginning and no end and is perpetual; the way it is with the heavenly bodies. In answer to the question who initiated this motion Aristotle postulated 'a mover which is itself motionless' which acted continuously on the outermost sphere. This mover was an immaterial substance, pure action devoid of power, and hence, itself motionless. The motion it impressed was due to some sort of attraction such as 'desire' or 'love'.

Aristotle regarded only upward and downward motions as natural. Any other motion, according to him, was unnatural and an unnatural motion, required continuous application of an external force. But then how to explain the motion of a projectile which continues to move even after the moving force has ceased to act on it? Aristotle tried to explain it by saying that the original projector still in contact with the projectile, sets in motion the adjacent layer of the medium during the process of its pushing the projectile. Moreover, the projector transfers to the medium a power to act as a mover itself, which power is transferred from layer to layer. As the projectile moves along, with each further transfer, this power weakens until it is overcome by its natural and vertically downward motion and thus the object comes to rest.

The above explanation of Aristotle was found to be only a speculative myth. On the contrary, we find that the impact (vega)

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of the Vaiśeshika was a highly developed concept.

Philoponus, in the sixth century A.D., explained the same by saying that the force which moves the projectile directly imparts to it a moving or kinetic power in which the medium has no contribution to make.

Further development of the theory of impetus in Europe occurred only in the thirteenth and fourteenth centuries A.D.

TIME

Atharvaveda contains a beautiful hymn in praise of time.[18]

VAIŚESHIKA CONCEPT

Time, according to Kanāda is his Vaiśeshika sutras, is one of the nine sub-varieties of the category Substance.

Praśastapāda in his Padārtha dharma samgraha says[19]: "Time is the cause of the contrary notions of 'priority', 'simultaneity', 'succession', 'late', 'soon' etc. It is the cause or basis of the production, persistence and destruction or (cessation) of all produced things; as all these are spoken of in terms of time. It is also the basis of such conventional usages as kśana, lava, nimeśa, kaśtha, kala, muhūrta, yama, ahoratra, ardhamāśa, māśa, ritu, āyana, samvatsara, yuga, kalpa, manvantara, pralaya and mahāpralaya—all measures of time, from a fraction of a second to millennia.

Qualities of time, according to Praśastapāda are: number, dimension, separateness, conjunction and disjunction.

It is eternal.

SĀMKHYA CONCEPT

Sāmkhya's views on time are more mature and penetrating.[20]

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18. AV XIX 53.
19. PDS IV 7.42.
20. Vyāsa Bhaśya on Patanjali's sutras. III 52 (as quoted by Seal, B.N. pp. 18-21).

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According to it, infinite time is a non-entity. Time can be divided and subdivided till it is so small that it can be divided no further. Basis of this division is the fact that any change in a substance is ultimately reflected in the atoms (pramānus) of that substance. A unit of such change *i.e.*, the transit of an atom (pramānu) or even a tanmātra from one point in space to the next succeeding point, is instantaneous and that can be taken up as an absolute unit of time. Two such absolute units cannot coexist simultaneously, neither do any series of moments exist in reality. Order in time is nothing but the relation of antecedence and sequence, between the moment that is and the moment that went just before. But only one moment, the present, exists. The future and the past have no meaning apart from potential and sub-latent phenomena. Only one single moment is actual and the whole universe evolves in that one single moment.

SPACE

VAIŚESHIKA CONCEPT

Space like time, is also one of the nine sub-varieties of the category, Substance, according to the Vaiśeshika system.

Praśastapāda says: "The character of space by itself is uniform and one only, yet for the sake of description, it is given ten different notions *viz.*, east, south-east, south, south-west, west, north-west, north, north-east, below and above.

Its qualities are: number, dimension, separateness, conjunction and disjunction.

SĀMKHYA CONCEPT

According to Sāmkhya,[21] space as locus or rather extension (deśa) must be distinguished from the relative spatial position (dik). The latter results only from the different relations in which

21. Vārtika of Udyotakāra, III 51 (as quoted by B.N. Seal, *Positive Sciences of the Hindus* pp. 21-22).

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the all-pervasive ākāśa stands to the various finite (or bounded) objects. Unlike time, it has no unit. On the other hand, space as extension or locus of a finite body (deśa) has an ultimate unit, being analysable into infinitesimal extensive quantity, inherent in the reals (gunas) of prakriti.

SOUND

Sound, according to Praśastapāda[22] is the property of ākāśa and is perceptible through the ear. It is momentary and has a limited existence. It is brought about by homogeneous and heterogeneous causes by conjunction or disjunction. It is counter-acted by its effect, its cause or by both.

Sound is of two types: (1) in the form of letters and (2) in the form of noise in general.

The former type proceeds from the contact of the mind and soul as influenced by memory. First of all there is desire of pronouncing the letter. This is followed by an effort on the part of the speaker and when this effort brings about the conjunction of the soul with air, there is produced in this air, a certain action (motion). This air moving upwards strikes such places as the throat and the like. This contact of the 'place' and the air brings about contact of the 'place' with ākāśa and this contact produces the letter-sound.

Noise is produced by the contact of ākāśa with such substances as the drum etc. Noise is also produced by such disjunctions as the splitting of a joints of a bamboo.

"Sound is always produced in a series, like the series of water-ripples, and when sound, appearing in the form of waves, reaches the ear, it is perceived. As the ear is not found to go to the sound (where it is produced), and the sound is not found to have actually come to the ear, and as there could be no perception of sound by the ear unless there were some sort of an approach of the one by the other, one cannot but accept the fact that the sound is produced in the form of a line or series of waves."

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22. PDS VI 10.137.

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9

Astronomy

INTRODUCTION

Recurring order of the morning, noon and night, of one season after the other and repetition of the same season after a large number of days and nights, must have been observed even by the most primitive of men in very early times. Increasing and decreasing size of the moon and repetition of the same process many times over in a set of seasons, would also have been noticed in due course. These bare observations provided man with a rough estimate of the time of the day, the number of days in the increasing and the decreasing phase of the moon *i.e.*, in a month, and the number of full moons, or the numbers of days after which a particular season recurs *i.e.*, a year. Man could now keep a record of the passage of time and thereby knew also when he ought to sow or to harvest his crop, or for that matter, how many sets of seasons (years) had passed since he was born.

Besides the recurring order of the day, the night and the seasons, the starry heavens attracted the attention of man. Initially he saw the sky with a sense of awe, admiration and curiosity. Then he observed that the heavenly sphere carrying the stars rotated from the east towards the west.[1] In this rotation of the sky he noticed that certain of the shiny objects[2] in the night-sky wandered about while the others maintained their relative positions. Gradually he noticed that the moon at night and the sun during the day time, moved along a certain fixed heavenly path[3]

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1. Of course, we know now that it is the earth that rotates.
2. Planets.
3. Zodiac—a belt or zone of the sky, sixteen degrees wide in which the sun, moon and planets travel. It contains the twelve zodiacal constellations.

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and that there were certain groups of stars in or near this path that could be used to quote the position of the moving objects, as for instance, it could be said that the sun (just before rising)[4] had reached near such and such a group of stars on a particular day or a season. Over the years, decades and centuries, it was noticed that it was the time for winter, summer, rains or for sowing or harvesting when the sun had reached near a particular group of stars. Passing of the sun through all these stars and its restart on the fresh journey in a particular number of days, which were nearly the same as the number of days it took for a particular season to recur, provided man with an alternative and relatively more accurate method of determining the number of days in a year.

This was man's first important landmark in his knowledge of astronomy.

HIGH STATUS OF ASTRONOMY

Calculation of the time was part of the sacred ritual with the Vedic Aryans. Religious sacrifices that they performed were of different types. While some of them were performed at a particular time of the day, the others were performed at full or new moon or when the days and nights were of equal length, and occasionally a sacrificial ritual lasted even for a year or more. Not only that, the sacrificial altar had to face a particular direction also, as for example, the east. So we see that the Aryans had to have a fairly broad-based idea of the time and the direction, from very early times.

Even during the early Vedic period in India, there was a class of men well-versed in the art of recognizing and noting the position of the various stars and calculating therefrom the time of the performance of different religious sacrifices. Yajurveda[5] mentions nakśatra-darsha (star-gazer) and ganāka (calculator or astrologer)

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4. Heliacal rising.
5. Y.V. XXX 10.

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as important functionaries in connection with the performance of these sacrifices. Chhāndogya Upanishad[6] mentions astronomy (nakśatra vidyā) as one of the subjects known to Narāda. It seems that this branch of knowledge had attained the status of a science worthy of study by the Brāhmanas. In the Grhya-sutras, a section of Kalpa-sutras, it is recorded that on arrival in their new home, the bridegroom pointed out to the bride the pole star (dhruva), indicating thereby the constancy of their wedded life. During the Sutra period, astronomy and astrology (Jyotisha) formed one of the six Vedāngas, the members of the Vedas. Jainas considered astronomy as one of the principal requisites in their priests.

ASTRONOMY IN ANCIENT INDIAN TEXTS

There is no regular text of astronomy available to us for the early stages of the Vedic period, which could tell us the amount of astronomical knowledge possessed by the Vedic Indians. Hence we have to depend upon the indirect references as given in different Samhitās and other texts of Vedic literature. These references, however, do reveal a lot of astronomical information, even though some of the inferences derived from them are not agreed upon by all the scholars.

RIGVEDA

The Rigvedic hymns that describe different heavenly bodies and phenomena are among the most beautiful. They are generally devoted to praising and describing the attributes of the celestial gods—the personified heavenly bodies. But when we try to sieve out the astronomical knowledge from them, we come against romantic vagueness and extravagant flights of imaginations of the poets. Some of the astronomical concepts discernible amidst such environments, are given in the following description, together with the relevant stanzas, so that we may have before us

6. Ch. U. VII, 1,2,4 ; 2.1 ; 7.1.

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as complete a picture as possible.

As we have seen already, Vedic Aryans worshipped different natural phenomena and worship of the rising sun was a daily ritual with them. Waiting for the sun to appear, with oblations in hand to offer to the god, was a daily practice then, as now. In the process of watching the sun to rise, the Vedic Aryans must have observed two things in its connection:

(1) That a particular group of stars was near it at a particular time of the year.

(2) That the point at which the sun arises varies at different times of the year, and this point travels in the north-south direction.

After watching the sun, daily for hundreds of days, it must have occurred to them that it takes about as many days for

(1) a particular season to recur

(2) for the sun to re-arise from the same point, and

(3) for the sun to re-arise with a particular group of star.

This gave them two other methods of finding out the total number of days in a year.

Now, the above three methods or more particularly the last two, of finding the number of days in a year, do not give exactly the same answer. Calculations based on them differ slightly. How the Vedic Aryans tackled this problem, we will see presently.

A Year, Its Months and Days: Rigveda mentions a year to have twelve months, 360 days and divided into four quarters of 90 days each :

> Formed with twelve spokes, by length of time, unweakened roles round the heaven this wheel of durable Order.[7]
>
> Twelve are the fellies and the wheel is single.
> Three are the naves. What man hath understood it ?
> Therein are set together spokes three hundred and sixty, which in no wise can be loosened.[8]

7. RV I 164.11.
8. RV I 164.48.

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He, like a rounded wheel, hath in swift motion set his ninety racing steeds together with the four.[9]

A year of 360 days was possibly an observation based on the rough method of counting the number of days in a year on the basis of the recurrence of the seasons, *viz.*, of spring, summer, autumn and winter—'the four quarters'.

But things could not have moved on smoothly with this rough calculation. After a few decades or even centuries, it must have been noticed that in a year of 12 months and 360 days, the seasons do not coincide with the months. Now it occurred to them that the other two methods of counting the number of days in a year, provided better correlation of the month with the season.

If there are more than 360 days in a year, then the problem arises how many months there are in a year? Should a year have a part of a month in it or should it only have a round number?

Vedic Aryans solved this problem by adding a full complete month of 30 days to a period of five years of 360 days each *i.e.*, five years were to have now $360 \times 5 + 30$ days $= 1830$ days, making an average of 366 days in a year. This provided better correlation of the months with the seasons. This period of five years was called a yuga—a cycle, which recurred. That is how the need to evolve the concept of a yuga was felt and executed.

That the Rigvedic Aryans noted the heliacal rising of the stars is indicated by reference to the heliacal rising of Sirius at the vernal equinox.

High in the mid ascent of heaven those Birds of beauteous pinion sit.

Back from his path they drive the wolf and he would cross the restless floods. Mark this my woe, Ye earth and heaven.[10]

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9. RV I 55.6.
10. RV I 105.11.

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A year of 366 days has also been deduced by some scholars on the basis that the 'twelve days repose of Ribhus', as mentioned in the following hymn, means that those twelve days were added to the 354 days of the lunar year, making a total of 366 days in a year.

When for twelve days the Ribhus joyed reposing as guests of him who never may be hidden,
They made fair fertile fields, they brought the rivers. Plants spread over deserts, water filled the hollows.[11]

Knowledge of an intercalary month—a month added in a lunar calendar to harmonize with the solar calendar in a cycle (yuga) of five years, has been interpreted to be implied in the following verse :

True to his holy law, he knows the twelve moons with their progeny :
He knows the moon of later birth[12].

The following two stanzas, respectively, have been interpreted to mean that the year commenced from the time of summer solstice, with the sun in the nakśatra Phalgunī.

They keep the twelve month's God's-appointed order,
and never do the men neglect the season.
Soon as the rain-time in the year returneth.
These who were heated kettles gain their freedom.[13]

The bridal pomp of Surya, which Savitar started moved along.
The Maghā days are oxen slain, in Arjunis they wed the bride[14]

11. RV IV 33.7.
12. RV X 85.13.
13. RV VII 103.9.
14. RV X 15.13.

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Sun: Sun is described as the source of light. It outstrips all other heavenly bodies in its speed of travel. It measures the day and the night and drives away the stars and the night, as one drives away the thieves.[15]

The seasons are made by the sun[16]. There is only one sun in the world[17] and that the rising and setting of the sun makes the days and the nights.[18]

Moon: The moon is said to be born again and again. Moon is said to make the seasons also. The sun and the moon 'ascend alternately and move in close succession'[19]. Of course, the moon plays a subordinate role only.

Planets:* Some knowledge of planets is implied in the following hymns. Number five or seven is considered to be suggestive of them. In some places seven and in other five planets are mentioned.

Seven sages guard with five Adhvaryus the Birds' beloved firmly-settled Station.[20]

May these five bulls which stand on high full in the midst of mightly heaven, the seven Adityas.[21]

Seven regions have their seven suns; the
ministering priests are seven,
Seven are the Aditya deities–with these O Soma,
Guard thou us.[22]

---

15. RV I 50.
16. RV I 95.3.
17. RV VIII 58.2.
18. RV IV 53.3.
19. RV X 85.18.

*A planet is a body revolving about the sun (excluding the comets, meteors, asteroids and the artificial satellites). There are nine known planets. They are non-luminous and reflect the light of the sun.

20. RV III 7.7.
21. RV I 105, 10.
22. RV IX 114, 3.

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Planet Jupiter (Brihaspati) is mentioned by name in the following hymn :

> Brihaspati, when first he had his being from mighty splendour in supremest heaven.
> Strong with his sevenfold mouth, with noise of thunder, with his seven rays, blue and dispersed the darkness.[23]

Jupiter is said to have been identified[24], in Rigvedic times, by Vāmadeva, son of Gotāma.

Another planet Vena, the Venus is mentioned in the following hymn.[25]

> This Vena, enfolded in the membrane of light, urges on (the waters) the germs of the sun in the firmament of water.
>
> The sages cherish him at the confluence of waters and the sun with endearments like a child.
>
> The cloud-born Vena sends the water from the firmament; the back of the azure (sky) is beheld.
>
> The Apsaras, smiling affectionately like a wife at her lover, cherishes him in the highest heaven: She wanders in the abodes of her beloved; he, Vena, being loved sits down on his golden wing.

ECLIPSES

Eclipses are mentioned but not their cause.

The hymn that says that, "The sun, whom Asura's son Svrabhānu had hidden was found out only by the Atri people, as no one else had power to find it,[26] perhaps, indicates that Atri people

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23. RV IV 50.4.
24. RV IV 50.4; AV XX 88.4.
25. RV X 123. 1.2.5.
26. RV V 40.9.

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had some idea of predicting the sun's eclipse.

NAKŚATRAS

In the following hymn, 'the 34 with light-like nature' is said to indicate 7 planets and 27 nakśatras.

He filled the heavens and earth and all between them, gods five times seven-fold in their proper seasons.

With four and thirty lights he looks around him,
lights of one colour though their ways are diverse.[27]

Some of the stars are mentioned by name.

The bridal pomp of Surya, which Savitar started, moved along.
In Maghā days are oxen slain, in Arjunis they wed the bride.[28]

Maghā and Arjuni are usually identified with the adjacent constellations Magha and Phalgunī.

Their offerings joy in rich juice where they value one, only one, beyond the Seven Rishis.[29]

The Seven Rishis denote the 'Great Bear'.

Other constellations said to have been mentioned in Rigveda are the Sirius and the Orion.

YAJURVEDA

A list of 27 nakśatras, commencing with Krittikā is clearly mentioned here[30]. It mentions that 'the full moon in Phalguni

27. RV X 55.3
28. RV X 85.13.
29. RV X 82.2.
30. TS. IV. 4.10.

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nakśatra is the beginning of the year'[31]. It also mentions that the moon shines because of the sun's light[32].

ATHARVAVEDA

It mentions an intercalary thirteenth month of thirty days[34] and thus clearly indicates the use of a cycle (yuga) of five years consisting of a total of $5 \times 360+30=1830$ days.

It also mentions, frequently, the eclipses. Demon of Rahu[33] is stated to be the cause of the eclipses and the gods Soma and Rudra[35] the remover of the eclipses.

Nakśatra list of Atharvaveda consists of 28 and it also mentions Sirius and the Orion group of stars.

BRĀHMANAS AND UPANISHADS

Śatapātha Brāhmana mentions an intercalary month of 35 or 36 days[36]. It also mentions Śhukra, the planet Mercury.

Aitareya Brāhmana says that "On the dark night the moon enters the sun, from where it is born"[38]. Taittiriya Brāhmana says about planet Brīhaspati (Jupiter): "When it was first born it was near Tishya nakśhatra"[39]. First born here, perhaps, means when it was first noted.

MAHĀBHARATA

Different references in Mahābharata divide the time since the

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31. T.S. VII 48.
32. TS. III. 4.7.
33. AV V 6.4 XII 3.8.
34. AV IX 9.10.
35. AV III 2.2.
36. SB IX 1.1.43, X 5.4.5.
37. SB. 4.2.1.
38. AB 40.5.
39. TB III 1.1.

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world existed, into four lengthy periods (yugas), namely, Krita, Traitā, Dvāpara and Kali. According to that, we are living in Kali-yuga and the former three yugas are already over. Mahābharata says that there will be dissolution of the world at the end of the Kali yuga.

The total number of years in these four yugas are said to be 12,000. All these are equal to one Deva-yuga, and 1000 Deva-yugas form one day of the Brahma, the Absolute. Some critics say that the number 12,000 years as the total life span of the earth is said in Deva-yugas and not in the years of the human beings[40].

Mahābharata does not mention the days of the week or even the week itself. The days were counted on the basis of the phases of the moon.

The cause of eclipses was said to be devouring of the sun or the moon by the demon of Rahu.

Planets are mentioned as five or seven in different places. In a very interesting and remarkable reference it says: "As five planets surround the sun, in the same way the five powerful and angry sons of Drupati surrounded the powerful monster of Alumbush and attacked him."[41]

This perhaps, shows that the sun was considered as the central point around which rotated the planets.

Different planets are mentioned in the following sequence: Venus, Jupiter, Mercury, Mars, Saturn, Rahu and the other planets.[42]

Another singularly remarkable observation is that, "the stars look small due to the great distance. In fact they are very large in size."[43]

Nakśatras herein number 27. Mahābharata refers to disappearance of one of the nakśatras, namely, Abhijit: "The lady Abhijit, the younger sister of Rohini has departed to the forest to perform

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40. Compare this with the total life since 4000 B.C., assigned by some Western sources, to the existence of the earth.
41. M.B. Bhishma parva 100.
42. M.B. III 230.0.
43. M.B. II 37.

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austerities and I am at a loss to form a substitute for the fallen star."[44]

PURĀNAS

Vishnu Purāna mentions the distances, in yojanas, of the orbits of different heavenly bodies from the earth as follows: Sun 100,000, moon 200,000, nakśatras 300,000, Mercury 500,000, Venus 700,000, Mars 900,000, Jupiter 1,100,000, Saturn 1,350,000, Great Bear (Saptarishi) 1,450,000, Pole Star (Dhurva) 1,550,000.

Pole star (Dhruva) is said to be the pivot around which the celestial sphere revolves. As the pole star revolves, it causes the moon, the sun and the stars to revolve also, as they are all bound to it.

VEDANGA JYOTISHA

While so far we have looked into other texts for astronomical knowledge, we will now have a look at a regular astronomical text, namely the Vedanga Jyotisha.

This is the first systematized text of Jyotisha of the Vedic period that is available to us now. It is said to have been composed by Lagadha, who lived sometime between 1200-900 B.C. The now available text of Vedānga Jyotisha seems, however, to belong to a period around the beginning of the Christian era. Calculations based on astronomical data provided in this text indicate that it was probably composed in Kashmir Valley.

Vedānga Jyotisha is available in two recensions, the Rigveda Jyotisha and the Yajurveda Jyotisha. Contents of both are similar; only the total number of the sutras (aphorisms) differ— Rigveda has 36 while Yajurveda has 44. Of these sutras only three-fourth concern astronomy proper. The principles of astronomy mentioned herein are in very condensed form and are sometimes

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44. M.B. III 42.24.

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even obscure. This had to be, as the text is not meant for the beginners.

Many scholars and orientologists have written commentaries on this text.

Division of the Ecliptic: In Vedānga Jyotisha, 27 nakśatras mark the 27 divisions of the ecliptic, each being equal to 13° .20. Chief characteristic of the text is that it gives the calculations of the positions of the sun and the moon relative to the nakśatras.

Yuga: A set of five years constitutes a yuga which consists of 1830 savana days—a savana day being the period from sunrise to next sunrise. This yuga contains 62 lunar months in it—a lunar month being the period between two new moons and has 29.516 savana days in it. (Value of the lunar month taken now is 29.530588 days, which thus indicate that the Vedānga's lunar month is slightly shorter than it should have been. To obviate even this difference, in later times, larger and larger yugas were constituted, even as long as of 432,0000 years). A year has sometimes thirteen months instead of the usual twelve, in a cycle of a yuga. This is to bring in harmony between the months and the seasons.

Savana Time: A savana month has 30 savana days and a savana day consists of 30 muhūrtas. One muhūrta is equal to 22 nādikās and one nādikā is equal to $10\frac{1}{20}$ kalās. There are 603 kalās in a savana day (sunrise to next sunrise).

Measurement of the Time: The time is measured by means of clepsydra. It consists of a metal vessel capable of holding certain fixed amount of water. It has a hole at the bottom. When the vessel is floated in a tub full of water, the water enters into it to fill it and then it sinks with a noise in a fixed time and that provides the unit of time.

Tithis (Lunar days): While a lunar month has approximately $29\frac{1}{2}$ savana days, it has 30 tithis in it[45]. Two lunar months have

45. A lunar month is the period between two new moons and it has approximately 29 32/62 days. It is less than the savana month by 30/62 part of a day. The lunar day (tithi) is less than a savana day by 1/62 part of a day. On the other hand, a savana month of a 30 days is less than the solar month of

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59 days and 60 tithis. Now if a correlation is to be established between the tithis and the savana days, every two months a tithi has to be dropped *i.e.*, if on a particular day it is tritiya tithi (third), then the next day though it ought to be chaturtithi, yet it is counted as tritiya again so that one tithi gets dropped. When was a tithi dropped, must have depended upon observations and there must have been some rules laid down about it.

Inherent Defect: The above description of the calculation of time shows that there was an inherent defect in the system of Vedānga Jyotisha and at best it could provide only an approximate but never the correct answer, and unless the total system was scrapped once for all, the adjustments could only be temporary. Unfortunately this was not done.

Main Purpose of Vedanga Astronomy: The main purpose of the astronomy of this period was to fix time for the performance of the religious sacrifices. Calculations of the time based on the principles mentioned in Vedānga were used even in the third century B.C. by emperor Ashoka to calculate the precise duration of his intended Buddhist pilgrimage. This fact shows clearly that Vedic astronomy was then in common use.

Basic teachings of Vedānga Jyotisha were incorporated later in the writings of the Jaina religion, which arose at about the same time as Buddhism *i.e.*, in the sixth century B.C. Jaina texts have helped to elucidate certain obscure passages in Vedānga Jyotisha.

SOME ASTRONOMICAL ENTITIES

NAKŚATRAS

We have already seen in the Rigveda that some of the stars or star groups (constellations)[46] are mentioned there by name and

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30 ½ days by half a day. For inter-correlation of the lunar and civil time, formulae are used and are given in the text. Most of the calculations of the time for the performance of religious sacrifices are based on the savana system.

46. Constellation is a pattern or group of stars apparently near together in the sky. Actually the individual stars of a constellation may vary enormously in distance from the earth and hence in relative distance from one another.

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their position is also indicated for a particular time of the year. This shows that even in very early times, the Vedic Aryans observed the stars and derived therefrom valuable information about the time of the year. While they observed the position of the stars, they also observed that the moon, as it moves along in the sky at night, is near a particular star on a particular day and as the moon completes its journey in the sky in approximately 27 days ($27\frac{1}{3}$), they marked the position of the moon on a particular night by a particular star, and thus they chose 27 stars for the 27 days journey. Now by just observing the position of the moon in relation to the particular star near it, they could tell the number of days that had passed since the beginning of the moon. This obviated the need to keep a daily record of the days passed etc. And this is how the 27 nakśatras of the Hindus arose.

Gradually, in the word nakśatra, the idea of a star or a star group receded, but the same word was used to indicate the 27 parts or divisions of the moon's path (also the sun's) called the ecliptic or zodiac. And this is what the word nakśatra indicated during the later Vedic period and after that.

As the moon completes its journey across the sky in $27\frac{1}{3}$ days, sometimes this division of ecliptic or nakśatras has been taken to be 27 and sometimes 28. Later texts struck on to the number 27, as that was convenient for calculations.

Vedānga Jyotisha clearly divides the ecliptic into 27 equal parts (nakśatras), while a Jaina text Surya prajnapati divides it into $27\frac{21}{67}$ equal parts. The latter text also says that the stars move faster than the nakśatras, which statement leaves no margin for doubt that the nakśatras meant divisions of the zodiac path.

Gargya is known to be the first person, according to Vedas, to have enumerated all these nakśatras. The following hymn in the Atharvaveda[47] lists their names and is associated with his name.

> Seeking favour of the twenty-eight fold wonderous ones, shining in the sky together, ever moving, hastening, in the creation (bhuvana), I worship with the songs the days, the firmament.

47. AV 19.7.

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Easy of invocation for me (be) the Krittikās and Rohini : be Mrigiśiras excellent (and) Ardrā-healthful, be the two Punarvaśus pleasantness, Pushya what is agreeable, the Aśleshas light, the Maghās progress (for me).

Be the former Phalgunis and Hasta here auspicious, be Chitrā propitious and Svāti easy for me; be the two Viśakhas bestowal, Anurādhā easy of invocation, Jyeshtha a good asterism, Mūla uninjured.

Let the former Ashadhās give me food, let the latter one bring refreshment; let Abhijit give me what is auspicious, let Śravana (and) the Śravishtha make good prosperity.

Let Satabhishak (bring) to me what is great widely, let the double Proshthapadas (bring) to me good protections: let Revatī and the two Aśvayuja (bring) fortune to me; let the Bharanī bring to me wealth.

Gargya is said to be the first person who enumerated all the nakśatras. When did Gargya live, is not known with certainty. He is said to have determined the position of various stars at the time of the birth of Lord Krishna. At the time of Mahābharāta, he was an astrologer to Arjūna. He was thoroughly acquainted with calculation of time by the observation of the stars. In Vishnu Purāna, we find a mythological story which tells that Gargya propitiated Śesha, the cosmic serpent and from it acquired the knowledge of the science of stars. Varāhamihira, in later times, mentions that the science of stars was enunciated by Narāda to Brihaspati and later on taught by Gargya, Parasara, Kaśyapa and Mayā to a number of other disciples.

Gargya Samhitā which was possibly composed about the beginning of Christian era is said to have embodied the teachings of Gargya. There are references about it in later works, but the treatise itself seems to have been lost long ago. In it, mention has been made of the Greek invasion of India and the

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subsequent conquest of those Greeks by a Śaka king who was himself later on conquered by another power. These episodes, we know now, occurred about the third century B.C. This treatise also mentions that, "The Greeks (Yavānas) are 'mlechchhas', but amongst them this science (of astronomy) is well established and therefore they are honoured as sages; how much more then an astrologer (should be honoured) who is a Brāhmana."

In later times, Varāhamihira's Brihat Samhitā appears to have been based on Gargya Samhitā.

Number of Nakśatras: The number of nakśatras mentioned in Atharvaveda and Maitrayaniya Samhitā is twenty-eight and in Taittriya Samhitā and Śatapātha Brāhmana it is twenty-seven. Though no satisfactory explanation for this is available, yet it is said that from the twentieth to twenty-third nakśatra, there is much overcrowding and here is situated Abhijit which is farthest removed from the ecliptic and so could be more easily left out than any of the other nakśatras. A division of ecliptic by twenty-seven gives each portion an even number of 800 minutes, while a division by twenty-eight gives an awkward and unmanageable number of $771\frac{3}{7}$ minutes. It may be that for the sake of convenience in calculations, in later times, the number of nakśatras was reduced from twenty-eight to twenty-seven.

First Nakśatra: While the early lists of nakśatras, as for example of Atharvaveda, begin with Krittikā (Pleiades), that of Vedānga Jyotisha begins with Śravishthā, of Mahābharata with Śravana, of Surya Siddhānta with Aśvini and of Surya prajnapati with Abhijīt. These form two groups—Krittikā to Aśvini and Śravishtā to Abhijit, separated by about one quarter of the ecliptic. It is said by some scholars that the explanation for this is the phenomenon of precession of the equinoxes which produced this effect over the centuries and this was well taken care of by the Indian astronomers.

Use of Nakśatras: Before the influence of Greek on Indian astronomy, these nakśatras were used to define position of the sun and the moon, as is evidenced by various texts of the period. Afterwards, however, their knowledge and use became redundant.

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Chinese and Chaldean ancient astronomy at some stage in their history also mention twenty-eight constellations on the ecliptic. There is mention of certain nakśatras even in Rigveda and there are hymns in it associated with the names of Śunahśepa, Vāmadeva and Vena Bhārgava, who are known to have been acquainted with the science of observation of stars. Though this points toward very old traditions of astronomy in India, yet it can not be said in unequivocal terms that the knowledge of these nakśatras is Indian in origin.

NAMES OF THE NAKŚATRAS

In connection with the names of the individual nakśatras, Griffith has given the following explanatory notes. His words 'lunar mansion' should be read as 'nakśatra as a division of the zodiacal path'.

Krittikā: One of the lunar mansions, Pleiades.

Rohinī: A lunar asterism personified as the daughter of Dakśa and the favourite wife of the moon. It is called Rohinī, the red, from the colour of the constellation's principal star, Aldebaran.

Mrigaśiras: The Antelope's head: a lunar asterism containing Orionis.

Ardrā: Moist, the fourth or sixth lunar asterism.

Punarvasu: The fifth or seventh lunar asterism.

Sūnrita: Pleasantness, a name of the Ushas or dawn.

Puśya: The sixth or in later times the eighth lunar asterism.

Aślesha: The seventh lunar asterism.

Maghā: The tenth lunar asterism, sometimes regarded as the wife of the moon.

Svāti: The star Arcturus, as forming the fifteenth lunar asterism.

Chitrā: Bright, Spica Virginis, the twelfth lunar mansion.

Phalgunī: Forming part of a double nakśatra, or lunar mansion, called also Arjuni.

Hasta: Hand: the thirteenth lunar asterism, identified by

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some with part of the constellation Corvus.

Rādhā: Success.

Vishākhā: One of the nakśatras or lunar mansion.

Anuradhā: Bringing welfare, the seventeenth lunar mansion.

Jyeshthā: The best, the sixteenth lunar mansion called also Jyesthāghni.

Mūla: The twenty-fourth lunar mansion.

Pūrva: Ashādhā, forming the eighteenth lunar mansion.

Abhijit: The twenty-seventh lunar mansion.

Śravana & Śravishthā: Lunar asterisms twenty-eight and one.

Śatabhishak: Requiring a hundred physicians; so-called because so many at least are needed to cure a person who falls ill while the moon is in this, the twenty-fifth asterism.

Prosthapadā: A double nakśatra, the third and fourth asterism.

Revatī: Splendid, the fifth asterism.

Aśvayuja: Two horse-harnessers; the head of Aries, forming according to one account the first and according other the sixth asterism.

Bharanī: Three stars forming the seventh asterism.

PITRIĀYANA AND DEVĀYANA

Rigveda[48] mentions Pitriāyana (going to the ancestors) in contra-distinction to Devāyana (going to the gods). Śatapātha Brāhmana[49] says that the seasons, autumn, winter and frost are the seasons that represent the ancestors (pitri) and the spring, summer and rains represent the gods (deva). It further says that when the sun moves southwards, it is amidst the ancestors (pitri) and it guards them but when it moves northwards, it is amidst gods and then it protects the gods.

For the words Pitriāyana and Devāyana, in later times,

48. RV X 2.7: X 98.11.
49. S. B. II 1.3.

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Dakshināyana (southern progress) and Uttarāyana (northern progress) were substituted.

Kaushitaki Brāhmana gives a clear description of how the point where the sun rises moves towards south, then it looks as if it is staying there for sometime and then moves back towards the north[50].

The above description indicates that from very early times, the Vedic Indians were familiar with solstices[51].

In Vedānga Jyotisha, the rules for calculating the positions and times of occurrence of the solstices are given. It states that they recur, in order, on the 1st, 7th, 13th, 19th and 25th lunar day and that the nakśatras in which the moon will be at successive solstices are the 19th, 11th, 3rd, 22nd, 14th, 6th, 25th, 17th, 19th. These results are based upon an interval of 183 days between successive solstices.

PHENOMENON OF PRECESSION[52]

We have already seen that the lists of nakśatras prepared at different periods by the Hindus, begin each time with a different nakśatra. This in itself is a clear evidence that the Hindus had knowledge of the phenomenon of precession and keeping that point in view they made the necessary corrections from time to time.

There are some other observations also to substantiate the above view.

1. The five year cycle (yuga) begins with the winter solstice in Śravishthā or Abhijit and with the summer solstice in Punarvasu.
2. Surya prajnapati text says that the planets travel faster

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50. K.B. IX. 2.3.

51. Solstice literally means a point at which the sun stands still. It is one of the two extreme points of the sun's yearly north-south travel. The summer solstice occurs about June 21st and the winter solstice about December 21st.

52. Precession is the slow change in the direction of the earth's axis caused by the gravitational pull of the moon upon the bulge at the earth's equator.

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than the stars and the stars faster than the nakśatras.

3. In the Purānas, it is mentioned that the Great Bear (Saptarishi) revolves among the nakśatras and a time of complete revolution is 2700 years.

All these above observations could only have been made if the phenomenon of precession was known.

As we know now, the actual amount of precession in longitude is about 50.26 seconds of arc of a year. In terms of time, it comes to a little over 20 minutes. Knowledge about the phenomenon of precession presupposes a correct knowledge of the length of time of a year, the sidereal[53] as well as the tropical[54]. Even if we take it that Indians did not possess that accurate knowledge about the length of a year, yet if the observations are extended over a longer period of time, in terms of decades and centuries, certainly the phenomenon of precession becomes apparent. It seems very likely that this is how the Vedic Indians learned about it.

VEDIC DAYS, MONTHS AND SEASONS

In Vedic times, there was neither the concept of a week nor of the days of the week. Days were counted according to the two phases of the moon. Parts of a day were two, three or four, but later on (as in Vedānga Jyotisha) a system of muhūrtas had come into being.

Rigveda clearly mentions a year of 12 months, and perhaps in the Rigveda and certainly in the Atharvaveda, a thirteenth month of 30 days in a period (yuga) of 5 years is mentioned.

Taittiriya Samhita[55] mentions the names of the seasons and the months as follows:

Spring season has two months: madhu and madhava; summer

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53. Sidereal year is the time which the earth takes to make one complete revolution round the sun.

54. Tropical year is the time between two successive passages of the sun through the same equinox. Sidereal year is longer than the tropical by difference due to precession.

55. TS 4.4.11.

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has two months; śukra and śuchi: rainy season has two months: nabhas and nabhasya; winter has two months: isha and urja; hemanta has two months: sahas and sahasya; śiśira has two months: tapas and tapasya.

Vājasyani Samhita[56] mentions a thirteenth month besides the above twelve. This month is called Ahmespati.

Taittiriya Brāhmana[57] mentions differently the names of the thirteen months. These are:

(1) Arunah, (2) Arunarajah, (3) Pundarikah, (4) Viśvajit (5) Abhijit, (6) Ārdrah, (7) Pinvamana, (8) Unnavān, (9) Rasavān, (10) Irāvān, (11) Sarvosadhah, (12) Sambharah, (13) Mahasvān.

These months were named after the name of the nakśatra that was nearest to the full moon in a particular month. Though we find this reference in Taittiriya Brāhmana, yet such a system of the names of the months came into vogue much later.

Thus we see that even in the early Vedic times, attempts were made to adjust the lunar with the solar system of reckoning time and to keep harmony between the months and the seasons.

Tandya Brāhmana, cautioning about the proper length of time of the year, mentions: ['If one day is not left out] the year will swell up like a leather water-bag'[58].

In early Vedic times, six seasons were counted and they were: the winter, spring, summer, rains, autumn, the hemanta or pre-winter. Sometimes hemanta and winter were counted as one season. Duration of each of these six seasons was two months, and winter began when the sun turned north (uttarāyana), and the rains when it turned south (dakshināyana).

Vedānga Jyotisha mentions six seasons of two months each in a year, and it takes a season as the time taken by the sun to pass through four and a half nakśatras. It also mentions the day when a particular season begins or ends.

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56. V.S. 22.31.
57. TB 3.10.1.
58. Tandaya B. 5.10.2.

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After Vedānga Jyotisha period, we do not have any astronomical text extant with us for the next about a thousand years. Kautilya śastra, around 300 B.C., mentions some astronomical observations. Surya prajnapati of the Jainas, around 200 B.C., mentions almost similar astronomical concepts as are in the Vedānga Jyotisha, except for its different cosmology with two suns etc.

Next, we hear of Āryabhata's astronomy in the fifth century A.D., which has a different background altogether.

After having gone through the astronomical knowledge possessed by the ancient Indians, let us have a look at the contemporary astronomy of the other ancient civilizations.

MESOPOTAMIAN ASTRONOMY

Astronomical records of Mesopotamia, the region between the rivers Tigris and Euphrates, go back to a very remote era—even as far back as 4000 B.C. These records, dating from the reign of Sargon of Akkad (3800 B.C.), indicate that different heavenly bodies were observed by expert observers.

There is evidence of the recording of the eclipse of March, 8th, 2283 B.C., which was believed to presage the fall of the city of Ur. The Mesopotamians discovered that the same eclipses recurred at the intervals of about 18 years or 223 lunations. This cycle of 18 years called Saros, in fact, tells the times when the sun, the moon and the earth are in a line. It is only at these times that an eclipse is possible. The eclipses, however, often fail to occur at these occasions as their orbits are not in the same plane, but that suited the Mesopotamian astronomer-priests because they could boast of that they had averted the eclipse and thus saved the country from calamity. For them the peril and censure was when an eclipse occurred which they had failed to predict.

EGYPTIAN ASTRONOMY

Not many records are available of the ancient Egyptian astro-

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nomy or of the observation or recording of the eclipses, as we have in the case of Mesopotamia. We, however, know that the Egyptian mathematics was rather poor and primitive and hence it can be surmised that their astronomy, which involves lot of mathematical calculations, must have been poor also.

The Egyptians had their own calendar during the third millennium B.C. They divided the year into twelve months of thirty days each. A year contained three seasons *viz.*, the inundation, the winter and the summer—each of four months' duration. These seasons seem to have been based essentially on the quantitative flow of water in the river Nile. They also added five extra days to each year making a total of 365 days in it.

There is evidence to indicate that they also observed various star-groups.

GREEK ASTRONOMY

Ancient Greeks took over much of astronomical knowledge of the Mesopotamians and Egyptians and advanced it further also.

Thales is known to be the first Greek to have put forward in a systematic way some of the astronomical observations and speculations. He considered the stars to be made up of fire and the moon to receive light of the sun. He placed the earth at the centre of the universe and said that it was spherical like a circular disc and that it was immobile.

The famous 'eclipse of Thales', in 585 B.C. which he is said to have predicted correctly, has not been authenticated by modern scholars. Even then, its story as told by Herodotus, indicates that the knowledge of the Saros and of forecasting the eclipses, was available to him.

Astronomical notions and speculations of different philosopher-scientists of the ancient Greece, beginning from Thales and upto Aristotle, have already been described in an earlier chapter of this book. Hence only a few other relevant observations will be made here.

Correlating the motions of the sun and the moon (so as to

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correlate the seasons with the months) and assigning a period at the end of which both again occupied the same position relative to the stars, had engaged the attention of the Greek astronomers also. For this purpose Meton and Euctemon formulated a cycle of nineteen lunar years, twelve of which contained twelve lunations each and the seven others thirteen lunations each. These latter seven were intercalated among the former twelve. Meton made this period consist of 125 full months of 30 days each and 110 deficient months of 29 days each, with a total of 6940 days for the 235 lunations. This period is nearly equal to 19 solar years. This cycle commenced on the 16th of July in the year 433 B.C. The event was celebrated by the people assembled at the Olympic games, and it was adopted in all the cities and colonies of Greek. Introduction of Metonic cycle marks an era in the history of early astronomy of Greek.

Aristarchus of Samos (about 270 B.C.) was an important Greek astronomer of the school of Alexandria. He, by an ingenious method, tried to determine the distance of the sun and the moon from the earth. Earlier, the Pythagoreans had taught that the sun is only three or at the most three and a half times, more distant than the moon. Aristarchus' observation in this regard though incorrect yet it expanded this distance. He also determined the diameter of the sun, which observation was nearly correct.

Aristarchus believed that the sun was stationary and the earth and other planets revolved around it.

Erastosthenes was successor of Aristarchus. He is said to have invented armillary spheres. He attempted to determine the magnitude of earth on correct principles *i.e.*, by measuring the angle between the ecliptic and the solsticial point.

Astronomy, which till then consisted only of knowledge of isolated facts, acquired a systematic form and almost a new existence by the work of Hipparchus, and three centuries later by Ptolemy.

CHINESE ASTRONOMY

Some astronomical observations were made in China even in

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very remote ages. Recording of eclipses was one of them. Emperor Fou-Hi in 2857 B.C., is said to have been fond of studying the motions and positions of the heavenly bodies. In the year 2608 B.C., Hoang-Ti, wanting to make a correct calendar, got an observatory made and appointed astronomers to observe the course of the sun, the moon and the stars. It was then discovered that the twelve lunar months do not exactly correspond with a solar year and that, in order to restore the coincidence, it was necessary to intercalate seven lunations in the space of nineteen years. This incidently indicates that the Chinese anticipated the discovery of what is known as Metonic cycle.

Emperor Yao in 2317 B.C., set astronomers to work on different astronomical fields afresh. Chinese division of zodiac into 28 constellations, called 'the houses of the moon,' is attributed to him. From him emerged the year consisting of $365\frac{1}{4}$ days and the division of the circle into $365\frac{1}{4}$ degrees, so that the sun described in its orbit an arc of one Chinese degree daily.

Calculations based on a lunar year of $364\frac{348}{940}$ days and the solar of $365\frac{1}{4}$, provided the Chinese a period of 4617 years, after which the sun and the moon again occupy the same relative positions.

Tcheou-Kong in 1110 B.C., observed meridional altitudes of the sun at the time of summer and winter solstices and thus established the obliquity of the ecliptic to be 23°.54′.3″. Another observation made about the same time relates to the positions of the winter solstice in the heavens, which is accurate within a minute of a degree.

Astronomy flourished in China upto the year 480 B.C. after which a rapid decline occurred. In the year 221 B.C. the emperor Tsiu-Chi-Hong-Ti, who was very much against various sciences including astronomy, is said to have got all the books burned and thus led to loss of valuable observations and knowledge.

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Arithmetic

As was the case with the knowledge of geometry which developed because of the necessity of making sacrificial altars, so was it with the art and science of calculation of numbers, knowledge of which was essential for calculating the exact time at which these sacrifices were to be performed. While knowledge of geometry remained confined within the walls of the altar, that of calculation of numbers blossomed further because it was needed, more so, for the day-to-day affairs of the social life of the people, as for instance for counting the number of cattle, the measures of grain, exchange of a particular quantity of goods for another.

STATUS OF ARITHMETIC

There is an oft-quoted story in Chhāndogya Upanishad[1] in which Narāda approaches sage Sanat Kumara and begs him to impart to him the Brahmavidyā—the Supreme knowledge. Before imparting such a knowledge, the sage wanted to make sure that Narāda deserved to know it and that he had already learnt the preliminary disciplines. So he asked Narāda to tell him what subjects he knew already. Thereupon Narāda enumerated what he knew and his list included astronomy (nakśatravidyā), and arithmetic (rashi-vidyā). This clearly shows that the science of arithmetic was one of the subjects of study during those days.

Vedānga Jyothisha[2] (900 B.C.) also gives arithmetic a very high place, when it says: "As the crests on the heads of peacocks, as

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1. Ch. Up. VII 1, 2, 4.
2. V.J. (YV) IV.

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the gems on the hoods of snakes, so is ganita (arithmetic) at the top of sciences."

Knowledge of Sankhyāna (the science of numbers) was one of the main requisites in a Jaina priest also[3] and with Jainas in general, ganitānuyoga (the exposition of the principles of mathematics) was one of the four main branches of knowledge. The same was the case with the Buddhists who regarded ganana (arithmetic) as one of the noblest arts.[4]

During Upanishadic period, the subjects of study of a student included lipi, lekh (alphabets and writing), rupa (drawing and geometry) and ganana (arithmetic). Prince Siddhārtha (the Buddha) began his education at the age of 8 years by first learning writing and then arithmetic, as two among the 72 arts and sciences that he learnt.[5] Arathaśāstra of Kautilya (400-200 B.C.) mentions that after the ceremony of tonsure, the student in those days was taught alphabets and arithmetic.[6]

Thus we see that arithmetic was regarded as one of the useful and important sciences in ancient India.

NUMERALS

SPOKEN NUMERALS

During the Vedic Period, beginning with the Rigvedic, there is a systematic mention of very high numerals in decimal order Medhatithi, with whose name, hundreds of verses of the Rigveda and some of the Yajurveda and Atharvaveda are associated, lists names of the numerals as follows.[7]

"O Agni, May these bricks be mine own milch-kine, eka (1)

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3. Bhagavati-Sutra. 90: also Uttarādhyayana-Sutra 7.8.38.
4. Vinaya Pitaka Vol. IV, p. 7 (Oldenberg's), Majjhima Nikāya Vol. I p. 85, Cullaniddesa p. 199.
5. Antagada-dasao and Anuttarvavaiya-dasao, English translation by L.D. Barnett, 1907, p. 30.
6. Arthaśāstra ed. by Shamaśastry I 5.2. English translation p. 10.
7. Yajurveda Samhitā (Vajāsaneyi) xvii. 2.

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and daśa (10), a śata (100), śahaśra (1000), an ayuta (10,000), a niyuta (100,000), a prayuta (1,000,000), an arbuda (10,000,000), a nyarbuda (100,000,000), a anta (10,000,000,000), a parārdha (1,000,000,000,000). May these bricks be mine own mich-kine in other world and in this world".

A parardha is thus 10^{12}

The above list also occurs at two places in Taittiriya Samhita[8] and slightly changed form of it in other texts[9,10,11].

High though these numerals are, they were developed further after the Vedic period. The following dialogue between Arjūna, the mathematician and Prince Gautama (Bodhisattva) in Lalitvistara,[12] a well-known Buddhist text of the first century B.C., is witness to that.

The mathematician Arjūna asked the Bodhisattva: O young man, do you know the counting which goes beyond the koti on the centesimal scale ?

Bodhisattva : I know.

Arjuna: How does the counting proceed beyond the koti on the centesimal scale?

Bodhisattva: Hundred kotis are called ayuta, hundred ayutas niyuta, hundred niyutas kankara, hundred kankaras vivara, hundred vivaras kśobhya, hundred kśobhyas vivaha, hundred vivahas utsanga, hundred utsangas bahula, hundred bahulas nagabala, hundred nagabalas titilambha, hundred titilambhas vyavasthana-prajnapati, hundred vyavasthana-prajnaptis hetuhila, hundred hetuhilas karahu, hundred karahus hetuvindriya, hundred hetuvindriyas sama-

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8. Taittiriya Samhitā IV, 40.11.4; vii, 2.20.1.

9. In Maitrayaniya Samhitā (II.8.14) the list has ayuta, prayuta, then again ayuta, then nyarbuda, samudra, madhya, anta and prardha.

10. In Kāthaka Samhitā (XVII, 10) the list is the same with the exception that niyuta and prayuta change places.

11. In Panchavimsa Brāhmana the list goes upto nyarbuda and then follow nikharva, vadava, aksiti etc.

12. Lalitvistara ed. by Mitra R.L. Cal. 1877.

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ptalambha, hundred samptalambhas gananagati, hundred gananagatis niravadya, hundred niravadyas mudrabala, hundred mudrabalas savarabala, hundred svarabalas visani jnagati, hundred visanijnagatis sarvajna, hundred sarvajnas vibhntanigana, hundred vibhutangamas is tallaksana.

Tallaksana is 10^{53}

And the following example[13] shows the highest numerals written in any of the ancient Indian texts.

"Daśa (10) multiplied by daśa (10) becomes śata (100), śata (100) multiplied by ten becomes sahaśra (1000), sahaśra multiplied by ten becomes daśa sahaśra (10,000), daśa sahaśra multiplied by ten becomes śata sahaśra (100,000) (also, called lakha), śata sahaśra multiplied by ten becomes daśa śata sahaśra (1,000,000), daśa śata sahaśra multiplied by ten becomes koti (10,000,000), hundred hundred thousand kotis give pakoti (also called koti koti $(10,000,000)^2 = 10^{14}$. In this manner the further terms are formed.

What are their names?

Hundred hundred-thousands is koti, hundred hundred-thousand kotis is pakoti, hundred-hundred-thousand pakotis is kotippakoti, hundred hundred-thousand kotippakotis is nahuta, hundred hundred thousand nahutas is akkhobhini; similarly we have bindu, abbuda, nirbbuda, ahaha, abada, atata, sogandhika, uppala, kumuda, pundarika, paduma, kathana, mahakathana, asankhyeya".

Asankhyeya is 10^{140}

One method of saying different numerals we have already seen above in which a single specific spoken word expressed the value of the numeral how-so-ever high it may be. There were other methods also, though more laborious, for doing the same during the Vedic and Upanishadic period. Let us have a look at them.

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13. Grammaire Palie de Kaccayana—J. Ascatique, Sixierne Serie. • XVII 1871, p. 411, explanation to Sūtras 51.52.

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WORD NUMERALS

In this method, things or concepts of common occurrence which always denote the same numeral, were used to express a given number, as for instance, the moon and the earth always stand for one single entity, and twins for two, and sky, void, and complete for zero.

The need for such a method of expressing numerals arose from the fact that the ancient Indian texts were composed in verse form and to have rhyme in the verses, it was necessary to have more than one word for expressing one numeral so that any one of them that fitted properly in the rhyme, could be used.

The following concise list of the numerals and the different words with which each one of them could be expressed gives some idea of this method of expressing numerals.

Different Words for Expressing the same Numeral:

0. Śunya (nil), gagāna, āmber, ākāśa, antariksha (all different names of the sky), nabha (naval).
1. Chandra, soma (two names of the moon), bhubhumi, kshiti, go, prithvi (all different names of the earth), pitamaha (the God).
2. Aśvin(twin celestial gods), netra, akśi, chakśu, nayana (different names of the eyes), bahu (arms), karna (ears), jangha (legs).
3. Guna, triguna (the three reals of Sāmkhya system), loka, trijagat (the three worlds) kala, trikala (time—past, present and future).
4. Veda, śruti (the four Vedas), varna (the four castes), yuga (the four periods).
5. Bhutas, mahabhutas, tatva (the five elements), prāna (five different kinds of breath).
6. Anga (four limbs and the trunk and head), ritu (the six seasons), darshna śāśtra (the six systems of the philosophy).
7. rishi, muni (the seven seers, seven stars in the constellation), svāra (the seven alphabets for singing).

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In similar fashion, numerals of two figures could also be expressed with different words. If larger numerals were needed to be expressed then the words were combined together *i.e.*, written one after the other so that long word chronograms were formed which expressed large numerals.

Historical Background of Such a System: In the Vedas, we do not find use of such a system, except occasionally when number twelve is meant to express a year, and number seven for the constellation with seven stars (śaptarishi). Fractions of one, however, have been expressed frequently, as for instance kala=1/16, kushtha=1/12, sapha=1/8.

The earliest example of a word being used to denote a numeral is in Śatapātha Brāhmana and Taittiriya Brāhmana. Chhāndogya Upanishad, Vedānga Jyotisha[14] and some of the śrauta-sutras[15] also have such instances. These instances, however, are rarities and do not indicate the prevalence of such a system.

Starting from Pingala Chhāndah-sūtra (200 B.C.) onwards till about 400 A.D., different astronomers and other people have used this system, and during this period it was quite popular. There is, however, no direct evidence that place-value was attached to these word numerals.

ALPHABETICAL NUMERALS

The defect in the above word-numeral system, as we have seen was that for large numerals, the word chronograms that were created, many a time, used to become too large and unwieldy and there was increased danger of mistakes creeping in. To obviate this, a system using only alphabets instead of the words was brought into practice and this became very popular with the astronomers.

The initial idea of using alphabets to denote numerals can be traced to, as far back as Pānini (C. 700 B.C.). He used vowels of

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14. Vedānga Jyotisha YJ 23, AJ 31, YJ 13, AJ 4, AJ 19, YJ 25, YJ 20.
15. Śrauta-sūtra of Kātyāyana (Weber's) p. 1015, and Lātyāyana IX 4.31.

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the Sanskrit alphabet to denote the number of sutras in his grammar, in the same way as we denote paragraphs by the letter a, b, c, d etc. For many centuries it just remained a dormant idea till about the fifth century A.D., when the astronomical science was blooming forth in India, attention was focussed on this idea and thereafter it became a regular system of writing numerals, alongwith the use of place-value notation of such alphabetical letters.

SYMBOL-SYSTEM OF WRITING NUMERALS

In the Rigveda, there is a verse[16] which has been interpreted to mean "Give me a thousand cows on whose ears the number eight is written". There must be some symbol for the number 'eight' which was marked on the ears of the cows—which practice prevailed in later times also. In another place in Rigveda,[17] a gambler says, "Having staked on 'one' (number 'one' on the dice) he lost his wife", which also indicates that there was a written symbol to denote number 'one'.

That writing was known to ancient Indians is clearly indicated by the writings on the stone seals discovered at Harappā, Mohenjo-daro and other sites of the Harappān civilization, belonging to a period as old as perhaps 2750 B.C. These discoveries leave hardly any doubt in mind that written numerals were known in India since those ancient times. But till such time as we can decipher these writings, we cannot know what symbols were used for these numerals.

The earliest written numerals of which we know the symbols and forms etc. belong to the Aśokan period. Megasthenes speaks of the mile-stones along the roads which bore the number of miles from a particular place—as is the custom now-a-days.

It has been postulated[18] that these numerals on the Aśokan inscriptions are derived from the Brahmi script. There are other

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16. RV X 62.7.
17. RV X 34.
18. Bhagwan Lal Indraji.

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scholars who do not, however, agree with such a view.

PLACE-VALUE

The system of denoting value of the numeral according to the place where it is put, was in vogue in India in the eighth century A.D., as is witnessed in various epigraphic finds. This place-value system was in decimal order, in the same manner as we have now all over the world. In no other country or civilization of the world was such a system in vogue as early as we find in India. Later on, it was through the medium of Arabian countries that the knowledge of this system spread over in Europe.

It is clearly understandable that the system of decimal place value notation in India must have been invented many centuries earlier for it to become a commonly used system in the eighth century A.D.

FRACTIONS

The idea of simple fractions of one, must have developed *pari passu* with that of the number of things, as for example, the number of cows, birds or stars, and the division of a bird or an animal between two hunters, each taking half a part, or a similar division among four in which case each limb of a quadruped went to a hunter.

Such fractions occur in Vedic literature since the earliest Vedic period. Rigveda[19] mentions one-half (ardha), and three-fourths (tripāda *i.e.* three of the four), Maitrāyaniya Samhitā mentions one-sixteenth (kala), one-twelfth (kustha), one-eighth (sapha) and one-fourth (pada) and in later times different Śulbas not only mention but also use composite fractions such as of 3/8 and 2/7 in different calculations.

While the most ancient texts of Egypt and Babylonia also mention fractions, there is nowhere mention of a composite

19. RV X 90.4.

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fraction 3/4 earlier than it is in the Rigveda.

SYMBOL FOR ZERO

While Brahmagupta, a later Hindu mathematician, is credited with the use of zero in its different mathematical operations, a text namely Pingala Chhāndah-sutra (200 B.C.) is said[20] to mention a symbol for zero. It says[21] in a reference:

"(Place) two when halved".
"When unity is substracted then (place) zero".
"Multiply by two when zero".
"Square when halved".

As early as 200 B.C., Hindus must have had a symbol for zero, to place it wherever it was needed, as the above reference indicates.

MEASURES

Precise weights and measures were in use in India even during the time of the Harappā civilization and such a tradition seems to have continued on later also.

MEASURES OF TIME

Śatapātha Brāhmana mentions the measures of time as follows:

30 muhūrtas in a day
15 kśipra in a muhūrta
15 itarhi in a kśipra
15 idani in a itarhi
15 prānas in a idani

In this fashion one prāna is equivalent to one-seventeenth of a second. Not that the ancient Hindus had any instrument to measure such small fraction of a second, yet it does show that

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20. Datta B.B.
21. Pingala Chhāndah-sūtra ed. by Śri Sita nath Cal. 1840 VIII 28/29/30/31.

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they appreciated the existence of minute fractions of time.

MEASURES OF LENGTH

Lalitavistāra[22] mentions, as follows, the scale of length as said to have been stated by the Buddha.

7 paramānu	1 renu
7 renu	1 truti
7 truti	1 vatayanaraja
7 vatayanaraja	1 śasharaja
7 śasharaja	1 edakaraja
7 edakaraja	1 goraja
7 goraja	1 eksaraja
7 eksaraja	1 sarsapa
7 sarsapa	1 yava (breadth of barley)
7 yava	1 anguli parva (breadth of finger)
7 anguli parva	1 vatasti
2 vitasti	1 hasta (cubit)
4 hasta	1 dhanu
1000 dhanu	1 krosha
4 krosha	1 yojana

According to the above table, the smallest measure of length, a paramānu $=1.3\times7^{-10}$ inch.

HINDU ALGEBRA

What we now call as algebraic problems, many of them were solved geometrically by the ancient Hindus, as is witnessed in the different Śulba-sutras. When in the Śulbas, a square is converted into a rectangle, it is, in fact, a solution of an equation with one unknown like a $x=C^2$. Similar is the case with many of the other problems as well.

Surds: Even surds (karani) and their addition, multiplication etc. are dealt with in the Śulbas. The terms used for different

22. Ed. by R.L. Mitra, Cal. 1877, p. 168.

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surds are divi-karani $\sqrt{2}$, tri-karani $\sqrt{3}$, trtiya-karani $\sqrt{1/3}$, saptāma-karani $\sqrt{1/7}$, astadaśa-karani $\sqrt{18}$ etc.

Baudhāyana and Āpastamba Śulba-sutras give almost correct value of the surds $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$ etc.

VALUE OF $\sqrt{2}$

For the value of $\sqrt{2}$, they both say[23]: 'Increase the measure (of which the dvi-karani is to be found) by its third part and again by the fourth part (of this third part) by the thirty-fourth part of itself (*i.e.* of this fourth part). (The value thus obtained is called) the saviśesa'.

This works out to be $\sqrt{2}=1.4142156$, which is very near to the correct answer 1.414213. How the ancient Hindus obtained such an approximate answer, has been postulated by Thibaut[24] in the following terms:

"The question arises: how did Baudhāyana or Āpastamba or whoever may have the merit of the first investigation, find this value. Certainly, they were not able to extract the square root of 2 to six places of decimal; if they have been able to do so, they would have arrived at still greater degree of accuracy. I suppose that they arrived at their result by the following method which accounts for the exact degree of accuracy they reached.

"Endeavouring to discover a square the side and diagonal of which might be expressed in integral numbers, they began by assuming two as the measure of a square's side. Squaring two and doubling the result, they got the square of the diagonal, in this case=eight. They then tried to arrange eight, let us say again, eight pebbles in a square, as we should say they tried to extract the square root of eight. Being unsuccessful in this attempt they tried the next number, taking three for the side of a square; but eighteen yielded a square root no more precise than eight had done. They proceeded in consequence to four, five etc. Undoubtedly they

23. BSL I, 61-2. Apsl I. 6.
24. Thibaut G. Science of the Sulbas, p. 189.

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arrived soon at the conclusion that they would never find exactly what they wanted and had to be contented with an approximation. The object now was to single out a case in which the number expressing the square of the diagonal approached as closley as possible to a real square number. I subjoin a list, in which the numbers in the first column express the side of the squares which they subsequently tried, those in the second column the square of the diagonal, those in the third the nearest square number.

1	2	1	11	242	256
2	8	6	12	288	289
3	18	16	13	338	324
4	32	36	14	392	400
5	50	49	15	450	441
6	72	64	16	512	529
7	98	100	17	578	576
8	128	121	18	648	625
9	162	169	19	722	729
10	200	196	20	800	784

"How far the sutra-kāras went in their experiments, we are, of course, unable to say; the list upto twenty suffices for our purposes. Three cases occur in which the number expressing the square of the diagonal of a square differs only by one from a square number: 8-9, 50-49, 288-289; the last case being most favourable as it involves the largest numbers. The diagonal of a square the side of which was equal to twelve, was very little shorter than seventeen ($\sqrt{289}=17$). Would it then not be possible to reduce 17 in such a way as to render the square of the reduced number equal or almost equal to 288?

"Suppose they drew a square the side of which was 17 padas long and divided it into $17\times 17=289$ small squares. If the side of the square could now be shortened by so much, that its area would contain not 289 but only 288 such small squares, then the measure of the side would be exact measure of the diagonal of the square, the side of which is equal to 12 ($12^2+12^2=288$). When the side of the square is shortened a little, the consequence is that two

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sides of the square a little stripe is cut off, therefore a piece of that length had to be cut off from the side that the area of the two stripes would be equal to one of the 289 small squares. Now as square is composed of 17×17 squares, one of the two stripes cut off a part of 17 small squares and the other likewise of 17, both together of 34 and since these 34 cut off pieces are to be equal to one of the squares, the length of the piece to be cut off the side is fixed thereby; it must be the thirty-fourth part of the side of one of the 289 small squares.

"The thirty-fourth part of the thirty-four small square, being cut off, one whole small square would be cut off and the area of the large square reduced to 288 small squares; if it were not for one unavoidable circumstance. The two stripes which are cut off from two sides of the square, let us say the east side and the south side, intersect or overlap each other in the south-east corner and the consequence is, that from the small square in that corner not 2/34 are cut off, but only $\frac{2}{34} - \frac{1}{34 \times 34}$. There the error is the determination of the value of the saviśesha. When the side of a square was reduced from 17 to $16\frac{33}{34}$, the area of the square of that reduced side was not 288 but $288 + \frac{1}{34 \times 34}$. Or putting it in different way, taking 12 for the side of a square, dividing each of the 12 parts into 34 parts (altogether 408) and dividing the square into the corresponding small squares, we get $408 \times 408 = 166464$. This doubled is 332928. Then taking the saviśesha-value of the diagonal into the small squares just described, we get $577 \times 577 = 332929$ such small squares. The difference is slight enough.'

"The relation of $16\frac{33}{34}$ to 12 was finally generalized into the rule: 'Increase a measure by its third, this third by its own fourth, less then thirty-fourth part of this fourth.'

$$16\frac{33}{34} = 12 + \frac{12}{3} + \frac{12}{3 \times 4} - \frac{12}{3 \times 4 \times 34}$$

The example of the saviśesha given by commentators is indeed $16\frac{33}{34} : 12$; the case recommended itself by being the first in which the third part of a number and the fourth part of the third

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part were both whole numbers.

Other explanations and procedures have also been put forward indicating the method of getting the value of $\sqrt{2}$.

Value of $\sqrt{3}$ and $\sqrt{5}$ was also tried to approximate quantities in the Śulbas.

Now that we have had a look at the arithmetical knowledge of the ancient Indians, let us see and compare it with that of the other ancient civilizations.

EGYPTIAN ARITHMETIC

Decimal system of numerals seems to have been known to the Egyptians since the third millennium B.C. They even had symbols for the numerals upto a million. These symbols were, however, such that they required many repetitions when large numbers needed to be expressed. In their system of numerals, they left an empty space where they wanted to signify zero. Of the fractions of one, they knew only those in which the nominator was always one, as for example, 1/4, 1/8, 1/10.

Egyptians knew of multiplication and division, but they performed these operations only by two and repeated many times the process for higher calculations.

They also had measures of length, weight and capacity, but these were generally unsystematic.

MESOPOTAMIAN ARITHMETIC

Mesopotamians used both a decimal (proceeding by tens) and a sexagesimal (proceeding by sixties) system of numerals. They knew of simple as well as composite (*e.g.* 3/4) fractions. They had more systematic measures of weights and lengths compared with the Egyptians.

They solved many of their geometrical and even astronomical problems algebraically.

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CHINESE ARITHMETIC

Since prehistoric times, Chinese have been using monosyllabic words for numerals upto 10 and also for hundred, thousand and ten thousand. As far back as thirteenth century B.C., they wrote numerals in decimal order, as for instance, they would write 759 as 700, 50, 9.

Chinese were ingenious in counting. They used small counting rods which they placed on the floor or a table and they set them in respective squares during counting. They put a rod in a square for tens after counting ten, and after having counted many tens in this way they lifted ten rods from the square of tens and in their place put one rod in a square for hundreds. And in this way they proceeded further. Then they simply expressed the number of rods in respective squares as: $9 \times 100 = 900$, $4 \times 10 = 40 + 3 = 943$.

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11

Geometry

The term for geometry in India, in ancient times, was 'Śulba'; the word being derived from 'sulb' or 'sulv' meaning to measure.[1] Its knowledge has become available to us through the texts called 'Śulba-sutras'. The word sutra means a short rule or aphorism and it indicates the style of the composition of these texts. The word Śulba-sutra, as a whole, thus means 'the short rules for making measurements'.

ŚULBA-SUTRAS

Different Śulba-sutras were meant as texts for those who had to construct altars in different geometrical shapes in connection with the performance of a variety of Vedic sacrifices. They contain rules, regulations and methods for construction of these altars and give us a good glimpse of the knowledge of geometrical principles and procedures known to the Vedic Indians.

In the Vedic literature, Śulba-sutras form part of the manuals of Vedic rituals called Śrauta-sutras, a division of the Kalpa-sutras, one of the six Vedāngas. In ancient times there were many more Śulba-sutras but presently only seven are known and available to us. They are of Baudhayana, Apastamba, Kātyāyana, Mānava, Maitrāyaniya, Vārāha and Vādula. Of these, the sutras of Baudhāyana, Āpastamba, Mānava Maitrāyaniya and Vārāha belong to Krišna Yajurveda and Kātyāyana belongs to Śulk Yajurveda.

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1. It was also sometimes called Rajju, meaning the thread, and it implied the art or science of making measurements etc. with the thread.

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A brief description of these Śulba sutras is as follows:

BAUDHĀYANA ŚULBA SUTRA

This[2] is the biggest and perhaps, the oldest of all the Śulbas. It is divided into three chapters. The first chapter contains 116 sutras of which the first two are just introductory, 3 to 21 define measures ordinarily employed, 22 to 62 give important geometrical propositions necessary for the construction of altars, and 63 to 116 give briefly the relative positions and spatial magnitudes of the altars. Second chapter consists of 86 sutras, of which 1 to 61 describe spatial relations of different altars and 62 to 86 describe elaborately construction of two (nitya) obligatory altars, namely the Garhapatya and Chhānda *i.e.*, the altar made, as it were, of the incantations rather than of bricks. The third chapter consisting of 323 sutras describes seventeen different (kāmya) altars for sacrifices to attain a definite objective, and these are fairly complex in nature. Much of this description is in minute details.

ĀPASTAMBA ŚULBA SUTRA

It[3] is divided into 6 sections, 21 chapters and 223 sutras. It gives important geometrical propositions essential for the construction of altars, describes relative positions of various altars and their spatial magnitudes and indicates methods for their construction also. The rest of it deals with the construction

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2. *Baudhāyana Śulba:* This was published by G. Thibaut with English translation, critical notes, extracts (from the commentary of Dvarakanatha Yajva) and a few diagrams, in the Pandit, a monthly journal, now defunct, of the Sanskrit college of Benaras: Old series, IV.X. (1874-5). New series I (1877). The text is printed in the Baudhāyana srauta sutra, being the 30th chapter of it, edited by W. Caland in three volumes, Cal, 1904.7.13.

3. *Āpastamba Śulba*: Edited & published by A. Burk, with German translation, notes, comments, helpful extracts etc. (from the commentaries of Kaparadisvami Karavindasvami & Sundararja) and diagrams, together with a masterly introduction, in the Zeit Schrift der deutschen moregenlandischen Gessellschaft, Lv. 1902, pp. 543-591: LVI 1903, pp. 327-391.

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of (kāmya) obligatory altars.

Baudhāyana and Āpastamba Śulba sutras deal with almost the same material and geometrical principles, with the difference that Āpastamba describes fewer obligatory (kāmya) altars.

KĀTYAYANA ŚULBA SUTRA[4]

Also known as Kātyāyana Śulba pariśista or Śulba pariśista, it contains a total of 90 sutras. The first part describe geometrical propositions, different measures employed, and the relative position and spatial relations of different altars except those of obligatory (nitya) ones (which are dealt with somewhere else in Kātyāyana Śrauta-sutra). The second part consisting of over 40 sutras gives interesting information about the measuring tape (rajju) and the gnomon. It also describes attributes of an expert altar-builder and rules for his conduct. This Śulba is written in a systematic form and provides useful information about the art of altar-building.

MĀNAVA ŚULBA SUTRA

It is a small but informative text. It gives description of the measuring tape, gnomon and different measures. It describes four methods of determining the cardinal directions (for the same, Kātyāyana Śulba śutra gives only three and Āpastamba and Baudhāyana none). Section two of it deals with relative positions, spatial magnitudes and the methods for construction of altars—even other than those mentioned in the first three Śulbas. The last section, besides describing other altars, also mentions the fees charged for the construction of altars.

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4. *Kātyāyana Śulba:* The first two chapters, were published by G. Thibaut with English translation and commentary, entitled the Śulba-sutra-vrtti of Rama (C. 1450 A.D.) in the Pandit New Series IV. 1882.

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MAITRĀYANIYA ŚULBA SUTRA

It is identical in many ways, with that of Mānava Śulba sutra and covers the same material.

VĀRĀHA ŚULBA SUTRA

It is closely related to Mānava and Maitrāyaniya sutras and some of the passages in it are the repetitions of the above two.

If we take into consideration the extent of geometrical knowledge revealed by different Śulbas, Baudhāyana, Āpastamba and Kātyāyana occupy prominent places; the other three being of only minor importance.

ORIGIN OF GEOMETRY

It was in connection with the Vedic sacrifices, in which sacrificial altars of different sizes and shapes were inherent part of the ritual, that the Vedic Indians learned and used geometrical principles, exactly in the same way as the study of astronomy was pursued for the performance of the same sacrificial rituals at exactly determined times.

Knowledge of geometrical principles and constructions etc., contained in the Śulbas comes, however, from much older sources —in fact from the time the sacrificial rituals started with the Aryans. This fact is explicitly mentioned and admitted in the Śulbas when they state in their texts, 'it is known', 'it is recognized' or 'prescribed by the authorities', 'thus they teach,' or 'it has been said' etc. There are innumerable references in the Rigveda about the construction of sacrificial altars, though, of course, we do not find mention of their different sizes and shapes—neither should we expect such information in the Vedas themselves. Taittiriya Samhitā[5] states the size of Āhavaniya, an obligatory altar, as one

5. TS V 2.5.1.

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square purśa and Śatapātha Brāhmana[6] describes Gārhapatya, again an obligatory altar, as a circle of one square vyama or puruśa and Āhavaniya as a square of the same size. This clearly indicates that Vedic Indians were familiar with the problem of squaring the circle. The Rigveda clearly mentions that there were experts available for construction of different altars and the name 'agnicit', a constructor of altars, is many times mentioned in Taittiriya Samhitā, Maitrāyaniya Samhitā, Śatapātha Brāhmana etc.

Yajurveda gives, in detail, the rites to be performed at the time of construction of altars, and Śatapātha Brāhamana in at least one-third of its contents, mentions various aspects of construction of the altars.

Thus we see that the knowledge of geometry contained in different Śulbas is derived from much earlier sources.[7]

SACRIFICES

Reference has already been made to different sacrifices and their altars. Let us see them in more detail so that the subsequent references to them become clear.

Different Vedic sacrifices can be described under two main categories, namely (1) Nitya *i.e.* indispensible and obligatory and (2) Kāmya *i.e.* optional, intentional and meant to achieve a special objective.

NITYA SACRIFICES

Some of them are supposed to be performed daily by every Vedic Hindu and their non-performance is a sin. Others are to be performed at special occasions, as for example, the seasonal ones. Nitya sacrifices can also be classified into three sub-groups as follows, according to the nature of oblation offered.

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6. SB VII, 1.1.37; VII 22.1.
7. See Garbe's Śrauta sutra of Āpastamba, Vol. III, Cal. 1902.

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(1) Iśti Yajna: These are performed with butter and fruit etc. as oblations; generally at full-moon and new moon.

(2) Paśu Yajna: Here the oblation is of an animal, as is the case with Niruddhapaśu bandha, which must be performed once every year.

(3) Soma Yajna: Soma juice is the essential oblation in it. This sacrifice is very costly and is ordained to be performed at least once in three generations.

KĀMYA SACRIFICES

These are optional. They are performed only by those who want to achieve a special objective.

ALTARS

The size and shape of the altar for a particular sacrifice must strictly follow the rules as even a little irregularity in it can nullify the object or have even adverse effect.

For nitya sacrifices, the three primary altars are Gārhapatya, Āhavaniya and Dakśina.

For kāmya sacrifices, the altars are more complex. Śyenacit *i.e.* falcon-shaped altar (fig. 1), the most ancient one amongst

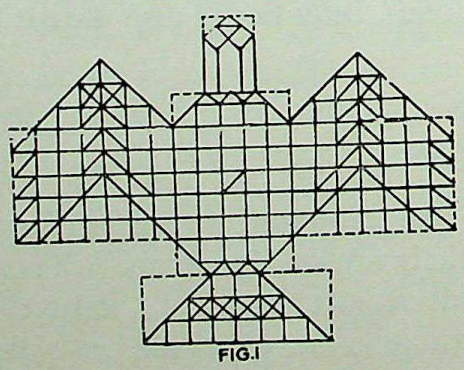

FIG.I

Śyenacit

them, has a body or trunk (ātman) consisting of four squares puruśa each; each of its two wings is a rectangle of $1 \times 1\frac{1}{5}$ puruśa and a tail a rectangle of $1 \times 1\frac{1}{10}$ puruśa. Other altars are in other

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different shapes, such as, that of falcon with bent wings and outspread tail, in the shape of a heron, an isosceles triangle, rhombus, chariot-wheel, trough, circular, in the shape of a cemetery or a tortoise. It is important to note that though all these altars are in different shapes yet their area remains the same *i.e.* $7\frac{1}{2}$ square puruśas.

Besides that, while an optional (kāmya) altar has an area of $7\frac{1}{2}$ puruśas when it is constructed for the first time, for a second and subsequent construction, its area increases by one puruśa each time till it reaches $101\frac{1}{2}$ puruŝas—but each time the relative proportions remain strictly the same.

Further complexity in altar construction comes in by the fact that every one of the five layers of the altar has a prescribed number of bricks of a specified shape, as for example, each layer of the 'falcon-shaped altar' has 200 square bricks only. Furthermore, in all the kāmya altars while their shapes are different yet the number of bricks that can be employed in their construction remain the same *i.e.* 200 only.

In the case of the three primary obligatory altars, the shape of Gārhapatya altar can be either square or circular, of Āhavaniya always square, and of Dakśina always semi-circular, and yet the area of each one of them has to be exactly equal to one square vyama (=96 fingers).

All these above factors try the skill of the altar-constructor and he has to know very well different geometrical principles for construction and conversion of the altars.

GEOMETRICAL CONSTRUCTIONS AND PRINCIPLES

Study of the shapes and sizes of different altars that were constructed in Vedic times and which are mentioned in different Śulba sutras, shows that the following geometrical (1) constructions and (2) principles must have been very familiar to the altar-constructors.

CONSTRUCTIONS

1. Construction of a square on a given straight line.

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2. Circling a square and *vice-versa.*
3. Doubling a square.
4. Constructing a rectangle with given sides.
5. Constructing an isosceles trapezium with given face, base and altitude.
6. Finding area of an isosceles trapezium.
7. Constructing an isosceles trapezium whose area will be equal to a simple multiple or sub-multiple of an other square.
8. Constructing a square equal to a simple or sub-multiple of another square.
9. Constructing a square equal to the sum or difference of two unequal squares.
10. Transforming a rectangle into a square and *vice-versa.*
11. Constructing a triangle or a rhombus equal to a square.

PRINCIPLES

1. A given straight line can be divided into any number of equal parts.[8]
2. A circle can be divided into any number of parts by drawing diameters.[9]
3. Each diagonal of a rectangle bisects it.
4. Diagonals of a rectangle bisect one another and they divide the rectangle into four parts, two and two vertically opposite of which are equal in all respects.[10] (Fig. 2).

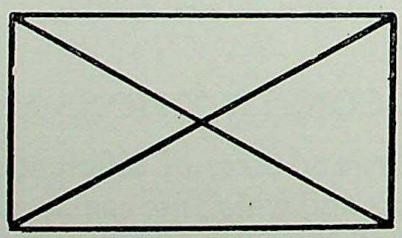

FIG.2

8. BSL. 1.59 etc.
9. BSL II. 77 etc.
10. The altar-constructors used to make bricks of the size and shape of the parts of such rectangles.

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5. Diagonals of a rhombus bisect each other at right angles.

6. A triangle can be divided into a number of equal and similar parts by dividing the sides into an equal number of parts and then joining the points of division two and two.

7. An isosceles triangle is divided into two equal halves by the line joining the vertex with the middle point of the opposite side.[11]

8. A triangle formed by joining the extremities of any side of a square to the middle point of the opposite of the sides is equal to half the square (fig. 3).

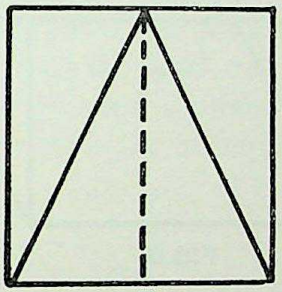

FIG.3

9. A quadrilateral formed by the lines joining the middle points of the sides of a square is a square whose area is half that of the original one (fig. 4).

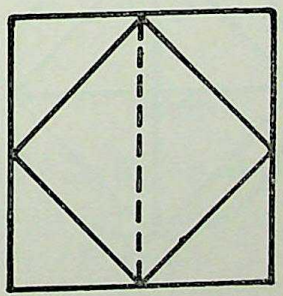

FIG.4

10. A quadrilateral formed by the lines joining the middle points of the sides of a rectangle is a rhombus whose area is half

11. BSL III 258.

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that of the rectangle (fig. 5).

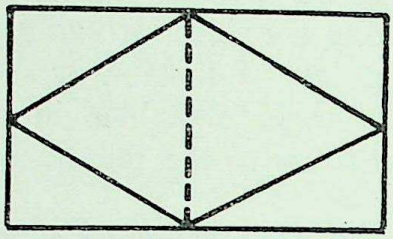

FIG. 5

11. A parallelogram and a rectangle which are on the same base and within the same parallels are equal to one another (fig. 6).

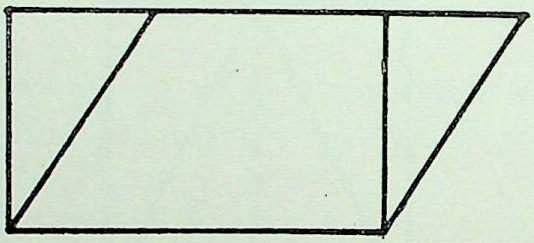

FIG. 6

12. The maximum square that can be described within a circle is the one which has its corners on the circumference of the circle (fig. 7).

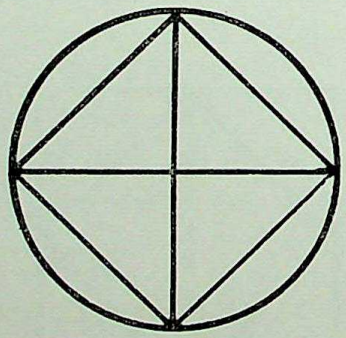

FIG. 7

13. The area of the square on the diagonal of a square is double the area of that square.

14. The area of the square described on the diagonal of a rectangle is equal to the sum of the areas of the squares described on its two sides.

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PROCEDURES

The following description of the different procedures employed by them is interesting since it tells how with the help of straight pieces of bamboo and cords, the altar-constructors could draw such intricate geometrical figures.

1. *Drawing a straight line at right angles to a given straight line.*

'On the given straight line A.B. fix two poles at an arbitrary distance apart and then, increase a cord of length equal to the distance between them (poles) by itself and make two ties at the ends. Then having fastened the two ties at the two poles, stretch the cord by its middle point towards the south and fix a pole at the place reached by the point. Proceed similarly on the north. It (the line joining these two poles) is the north-to-south line.'[12] (Fig. 8).

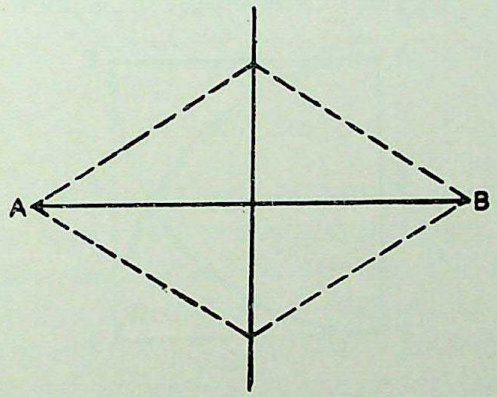

FIG:8

2. *Constructing a square having a given side.*

There are five different and interesting methods that are described for it. They are as follows.

Method I.

'In a bamboorod, make two holes (A, B) as much apart as the height of the sacrificer with uplifted arms and a third hole (C)

12. KSL I. 3.

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midway between them. Place the bamboorod on the east-to-west line and fix poles in the holes (beginning) from the western extremity of the sacrificial place. Then freeing the two poles (C, B) on the west, describe a circle (by rotating the bamboo) south-eastwise by the hole at the (opposite) end. Then unloosening the eastern hole and fixing the hole in the west (in its original position), describe another circle south-west-wise by the hole at the opposite end. Now release the bamboo (completely); fix again an extreme hole at the middle pole (C); place it towards the south over the point of intersection of the two circles and fix a pole at the point (F) reached by the outermost hole. Then fix at the pole the middle hole of the bamboo and having laid it along the extreme outer edges of the two circles, fix two poles (E, D) at the two (outermost) holes. It (the figure thus described ABDE) is a square (having a side) of one puruśa'[13] (fig. 9).

This method seems to be the oldest for such a construction.

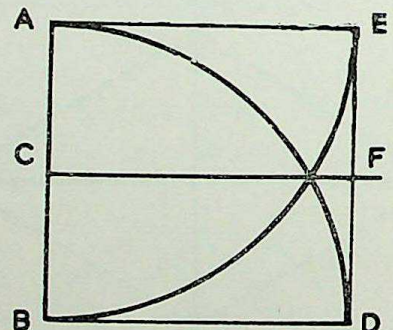

FIG. 9

Method II.

'If you wish to construct a square, take a cord as long as its side is desired to be; make a tie at both ends and a mark at the middle. Then having drawn a line (east to west) of the desired length, fix a pole at its middle. Fasten the two ties at this pole and describe a circle with the mark. Now fix poles at both the ends of the diameters (running east to west). Having fastened one tie at the eastern pole, describe a circle with the other tie.

13. APSL. VIII 8-10; XI. 1.

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Describe a similar circle about the western pole. On joining the points of intersection of the circles, the second (*i.e.* north to south) diameter will be found. Fix two poles at the extremities of this diameter. Now, having fastened both ties at the eastern pole, describe a circle with the mark. Similarly describe circles about the southern, western and northern poles. The exterior points of intersection of these circles will determine, the square'[14]. (Fig. 10).

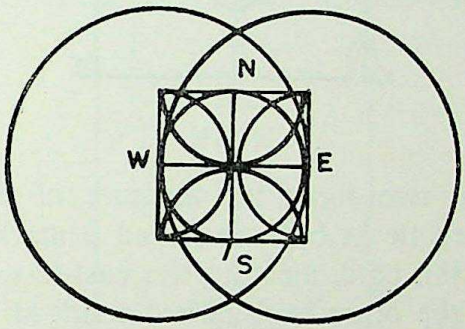

FIG 10

Method III.

'Take a cord as long as the measure (to be given to the side of the square); make a tie at both ends and the mark at the middle of itself and of its two halves. Stretch out this cord along the east-west line and fix poles at the ties and marks. Then having fastened the ties at the two poles of outer marks, stretch the cord towards the south having taken it by the middle mark and make a point there. Now fasten both the ties at the middle pole and stretch the cord towards the south by the middle mark over this point and fix a pole at the place reached. Fasten one tie at this pole, another tie at the eastern-most pole and stretch out the cord having taken it by the middle mark; thus will be obtained the south-eastern corner of the square (required). Then freeing the tie from the eastern-most pole, fasten it to the western-most pole and again stretch the cord by the middle mark; thus the south-western corner will be determined. Similarly can be determined

14. BSL I 22-28.

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the north-eastern and north-western corners of the square'[15] (fig. 11).

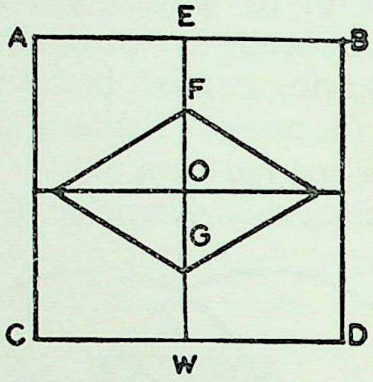

FIG.11

Method IV.

'Take a cord two times the measure of the given side of the square; make a tie at both ends and a mark at the middle; with one-half of this cord, measure the east-to-west (breadth) of the square. In the other half, make a mark at a distance (from the western end) less by its one-fourth. Let this mark be called nyanchāna. Make another mark at the middle of that half for the purpose of (determining) the eastern corners. Having fastened the two ties at the two extremities of the east to west breadth, stretch the cord towards the south by the nyanchāna mark. Thus the two eastern and two western corners of the square should be constructed by the middle mark of the other half of the cord'[16] (Fig. 12).

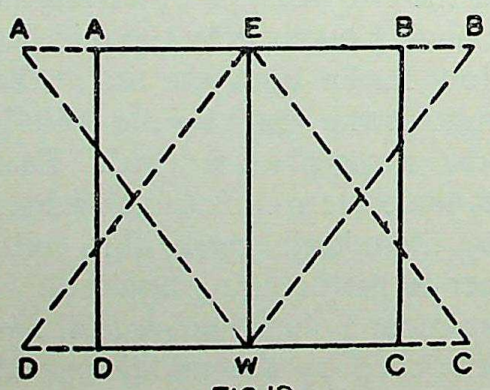

FIG.12

15. APSL I. 7.
16. BSL I. 29-35.

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Method V.

'Add to a cord as long as the given side its half and make a mark at a distance (from the other end of the added portion) less by its sixth part. Fasten the ends of the (increased) cord at the extremities of the east-west line and stretch it towards the south having taken by the mark and put a sign at the point reached by it. Do similarly on the north and again on both sides after interchanging the ends of the cord. This is the construction'[17] (Fig. 13).

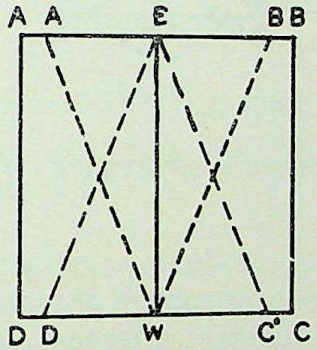

FIG. 13

3. *Constructing a rectangle of given sides.*

'If you wish to construct a rectangle, fix on the ground two poles as much apart as you wish (the length to be). On either side (before and behind) of each of these poles, fix two other poles at equal distance from it. Take a cord as much as the breadth (of the rectangle); make a tie at both ends and a mark at the middle. Having fastened the two ties at the two poles about the eastern pole, stretch the cord towards the south by the mark and put a sign (where the mark touches the ground). Then fasten the two ties at the middle pole and again draw the cord over the sign towards the south by the mark and fix a pole at the mark. That is the south-east corner (of the rectangle). Thereby is explained (how to determine) the north-east corner and also the

17. APSL 1.

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two western corners"[18] (Fig. 14).

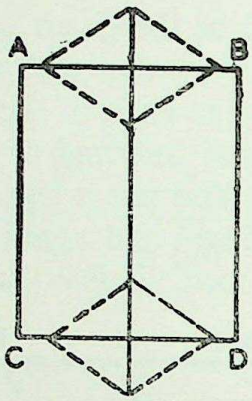

FIG. 14

4. *Constructing an isosceles trapezium of a given altitude, face and base.*

Baudhāyana, for this, follows a method similar to the one adopted by him for the construction of a rectangle of given sides. Āpastamba gives four different methods, all based on the same principle. Āpastamba can, however, construct such an isosceles trapezium with two cords or even one cord with equal facility.

Method using one cord only.

'Add to a cord of 36 (pada or prakramā) 18 and make a mark at 12 from its western end. Having fastened the ends of the cord to (the poles at) the two extremities of the east-west line (of 36 pada), stretch it towards the south by taking by the mark at 15 and fix a pole (at the point reached by the mark); (proceed) similarly towards the north. These poles are the two western corners of the altar. For (determining) the two eastern corners, interchange (the ends of the cord) and then stretching it towards the south by the mark at 15, fix a pole at (the point reached by) the mark at 12; (proceed) similarly towards the north. These are the two eastern corners. This is the method of construction with one

18. BSL I. 36-40.

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cord'[19] (Fig. 15).

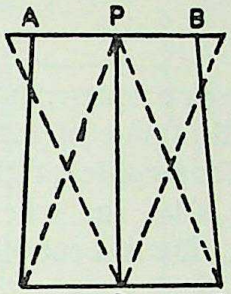

FIG.15

5a. *Drawing a square equivalent to n-times a given square.*

Different methods are given for this in different Śulbas. Kātyāyana's method is as follows:

'Twice the measure (of a side of a given square) is (its) four-fold-producer; thrice the measure is the nine fold-producer. As many units of a measure as are in a cord, so many rows (or series) of squares (of that measure) there will be in a square on that cord as side. Combine them.'[20]

To get converse of the above *i.e.*, to draw a square equivalent to n-th part of a given square, Kātyāyana[21] further describes, after the above method: 'thereby is explained the generator of the third part. Division of the given measure into 9 parts and the same applies to n-th part'.

5b. *Drawing a square equivalent to the sum of two different squares.*

The method given for this in different Śulbas is the same. Kātyāyana[22] says: 'To combine two different squares, cut off from the larger a (rectangular) portion with a side of the smaller one. The diagonal of this segment will be a side of the sum'.

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19. APSL V. 2.
20. RSL III. 6-9.
21. KSL II. 15-16.
22. KSL II. 22.

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5c. *Drawing a square equivalent to the difference of two different squares.*

The method is:

'To deduct a square from a square, cut off from the larger a (rectangular) segment with a side of the square which is to be deducted. Then draw a longer side of this segment diagonally across to the other long side; and where it falls (on the other side), cut off that portion. By this cut-off portion, the deduction is finished'[23] (Fig. 16).

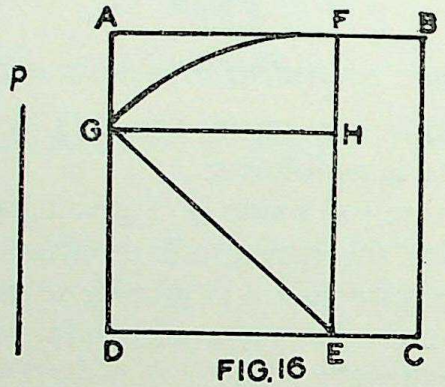

FIG. 16

Other operations described are 'To draw a square equivalent to two given triangles', and 'to draw a square equivalent to two given pentagons'.

6a. *Changing a rectangle into a square, area remaining the same.*

Baudhāyana says:

'If you wish to transform a rectangle into a square, make its breadth as the side of the square; divide the remainder into two parts and changing the place (of the farther one of them) and inverting, add it on the other side of the square. Then adding a (square) portion, fill up that (the empty space in the corner). It has been taught (before) how to deduct it (the added square from the full

23. BSL I. 51; APSL II. 5; KSL III. 1.

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square thus formed)'[24] (Fig 17).

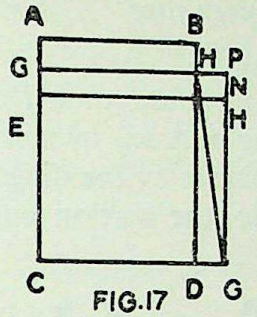

FIG.17

6b. *Converse of the above: Changing a square into a rectangle.*

The same author says: 'If you wish to transform a square into a rectangle, divide it by the diagonal. Divide again one part into two and add them suitably so as to fit the two sides (of the other half)'[25] (Fig. 18).

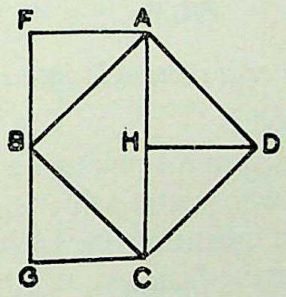

FIG.18

6c. *Changing a square into a rectangle which shall have a given side.*

Āpastamba's method is:

'If you wish to transform a square into a rectangle (cut off from it a rectangular segment) by making a side as long as you wish (a side of the transformed rectangle to be). What remains in excess, should be added (to the former) as suitably as to fit.'[26]

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24. BSL 1.58
25. BSL I. 52 ; also KSP III. 4
26. APSl III. 1 ; also BSL 1.53

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6d. *Changing a square or a rectangle into an isosceles trapezium which shall have a given face.*

Baudhāyana's method is:

'If you wish to make a square or a rectangle shorter on one side (cut off a rectangular portion) by making the shorter length a side. Divide the remainder by the diagonal and place (the two portions) on either side (of the portion cut off) after inverting'[27] (Fig. 19).

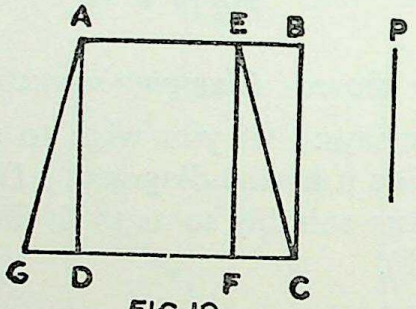

FIG.19

6e. *Changing a square or a rectangle into a triangle.*

Baudhāyana's method is:

'If you wish to transform a square or a rectangle into a triangle, construct a square whose area will be twice as much as the area of the figure (to be transformed). Fix a pole at the middle of its eastern side. Having fastened at it two ties (of two cords), stretch the cords towards the two western corners. Cut off the portions lying beyond these cords'[28] (Fig. 20).

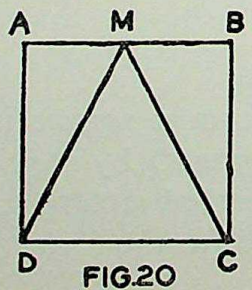

FIG.20

27. BSL 1.55.
28. BSL 1.56.

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6f. *Changing an isosceles triangle into a square.*

Kātyāyana's method is:

'If you wish to transform an isosceles triangle into a square, cut off its northern half by the middle line; then place it on the opposite side after inverting. By the method of constructing a square equal to a rectangle, construct the square. This is the method of construction'.[29]

6g. *Changing a square or a rectangle into a rhombus.*

Baudhāyana's method is:

'If you wish to transform a square or a rectangle into a rhombus, construct a rectangle which shall have an area twice as much as the area (of the figure to be transformed). Fix a pole at the middle of its eastern side. Having fastened at it two ties (of two cords), stretch the cords toward middle (points) of the northern and southern sides (of the rectangle). Cut off the portions lying beyond (these cords)'[30] (Fig 21).

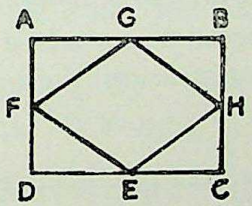

FIG.21

6h. *For the converse of the above.*

'If it be the case of (transformation into a square of) a rhombus, bisect it by its transverse middle line. Then construct as before'.[31]

7a. *Circling a square.*

'If you wish to circle a square, draw half its diagonal about the centre towards the east-west line; then describe a circle toge-

29. KSL IV.5.
30. BSL 1.57.
31. KSL IV. 6.

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ther with the one-third of that which lies outside (the square)'[32] (Fig. 22).

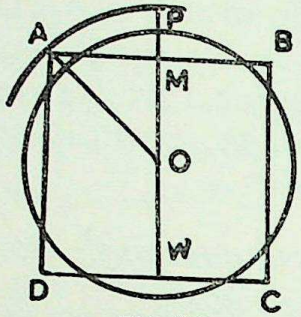

FIG.22

7b. *Converse of the above: Squaring a Circle.*

'If you wish to square a circle, divide its diameter into eight parts; then divide one part into 29 parts and leave out 28 of these; and also the sixth part (of proceeding subdivision) less the eighth part (of the last)'[33,34].

8a. *Measurement of the area of a square.*

'As many units of measure as are in a cord, so many rows (or series) of squares (of that measure) there will be in a square on that cord as a side'[35].

8b. *Measurement of the area of an isosceles trapezium.*

Mahāvedi with an altitude, face and base of 36, 24 and 30 padas, forms an isosceles trapezium and its area is measured as follows:

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32. BSL I. 58; APSL III. 2; KSL III. 13.

33. BSL I. 59.

34. As we have already seen, the three primary altars (obligatory), namely, Gārhapatya, Āhavaniya and Dakśina had to be of the same area but of different shapes: the first circular, the second square and the last semicircular. Among them, Gārhapatya and even Dakśina could have either circular or a square shape but the area in each case had to remain the same. Taittiriya Samhitā and Śatapātha Brāhamana mention these facts in connection with the construction of these altars. All this clearly shows that the problem of squaring a circle and vice-versa was well known to Indians as far back as that time.

35. APSL III. 7; KSL. III. 9.

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'The mahāvedi measures (in area) one-thousand less twenty-eight (square) padas. Draw a straight line from the south-eastern corner (of the vedi) to a point 12 padas towards the south-western corner. Place the portion thus cut off on the other (*i.e.* northern) side of the vedi after inverting it. It (the mahāvedi) will then become a rectangle. After that construction, the area will be apparent.'[36]

9a. *To construct a square having an area of 108 square padas.*

'One-third producer (*i.e.* the side of a square whose area is one-third the area) of the square made with the third part of the mahāvedi is that (the side of the partrki vedi). Its area is the ninth part of the area (of the mahāvedi whose area is 972 padas)'.[37]

9b. *To construct an isosceles trapezium having area of 324 square padas.*

'If a square be formed with the third part of the mahāvedi, its sides will be each 18 padas long. Then by making it longer on one side and shorter on the other, the sides should be determined optionally as necessary'.[38]

It appears that the altar-makers also knew about measuring (1) Volume of a prism and (2) Volume of a cylinder.[39]

10a. *To construct an isosceles trapezium similar to a given isosceles trapezium but with a third part of its area.*

Construct 'with $1\sqrt{3}$ of a prākaramā being substituted for a prākramā therein; or with 8 and 10 times $\sqrt{3}$, as the transverse sides and 12 times $\sqrt{3}$ as the east-west line'.[40]

10b. *To construct a similar falcon-shaped altar but differing in area by m-puruśa from its original of $7\frac{1}{2}$ puruśas.*

'Divide that which is to be the difference from the original

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36. APSL V. 7.
37. BSL I. 82.
38. BSL I 86-7.
39. Datta B.B. *Science of Śulbas* (1932) p. 101.
40. APSL V. 8; KSL II. 19

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(given) size of the altar into 15 equal parts; add to each of the constituent portions (vidha *i.e.*, units) of the given figure two of these parts. Then construct a figure (in the same way as the given one) with $7\frac{1}{2}$ of these (altered) units'.[41,42]

12. *To estimate area of the square on a diagonal of a rectangle.*

The answer is: 'The diagonal of a rectangle produces both (areas) which its length and breadth produce separately.[43,44]

RATIONAL RECTANGLES

Rational rectangles are those whose sides and diagonals are rational integers, as for instance, $3^2+4^2=5^2$. There are quite a few examples of these in the Śulba sutras. As to how the ancient Hindus came to understand them, not much internal evidence is available.

Explanation put forward by Thibaut, the German orientologist, who was very much interested in Śulba sutras, is as follows[45]:

"Most likely they discovered that the square on the diagonal of an oblong, the sides of which were equal to three and four, could be divided into 25 small squares, sixteen of which composed the square on the longer side of the oblong, and nine of which formed the area of the square on the shorter side. Or, if we suppose a more convenient mode of trying, they might have found that twenty-five pebbles or seeds, which could be arranged in one

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41. BSL II. 12.

42. We have already seen that the 'falcon-shaped' altar, at first construction has an area of $7\frac{1}{2}$ puruśas, which increases by 1 puruśa each time it is further constructed till the area is increased to $101\frac{1}{2}$ puruśas. The earliest reference to such a procedure is found in Śātapātha Brāhmana (X.2.3.6.) This indicates that the knowledge of changing the area but keeping the figure, was known in India at least since that time.

43. BSL I. 48; APSL I.4; KSL II.11.

44. The same proposition stated in a different form is called as Pythagorean theorem, attributed to Pythagoras (c 540 B.C.)

45. Thibaut, G. (1875) *On the Śulba sutras.* J. Asiatic Soc. of Bengal, XLIV, p. 227-275.

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square, could likewise be arranged in two squares of sixteen and nine. Going on it that way, they would form larger squares, always trying if the pebbles forming one of these squares, could not as well be arranged in two smaller squares. So they would form a square of 36, of 49, of 64 etc. Arriving at the square formed by $13 \times 13 = 169$ pebbles, they would find that 169 pebbles could be formed in two squares, one of 144, the other of 25. Further on, 625 pebbles could again be arranged in two squares of 576 and 49 and so on."

Datta, however, did not agree with Thibaut and put forward the case as follows[46] : He said, "Thibaut supposes that the Hindus had, starting from a greater square, obtained two smaller ones by division. Burk, on the other hand, supposes that they started more likely from a smaller square and found that the new square formed by increasing it, was the sum of two smaller ones, the original square and the square formed by the added portion. This supposition, indeed, tallies more with the procedures found in the Śulbas. For instance, take the method of construction of the Sara-ratha chakra-cit described by Baudhāyana. There one has to make, as an auxiliary construction, a square with 225 plus 64, altogether 289 square bricks. Baudhāyana says: 'With these bricks a square is to be formed. The side of a square (first formed) comprises sixteen bricks. Thirty-three bricks will still remain in excess. With them construct the borders (on two sides) completely round.'[47]

"It will seem strange," says Datta, "that instead of being directed to construct the whole square at once, we are told to make at first a square with 256 bricks and then to place the remaining 33 bricks around its two sides. As has been rightly pointed out by the commentator, this rule must be explained by the fact that the process of construction really began with a square consisting of bricks. Next square was constructed by placing 5 squares along its two sides, so that it contained 9 bricks. Proceeding thus and placing the

46. Datta B.B. *Science of the Śulbas* (1932), p. 125.
47. BSL III. 191-4.

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additional bricks alternately on the north and east sides and on the south and west sides, a square of 256 bricks was constructed without disturbing the position of symmetry of the altar about the east-west line. But the addition of the remaining 33 bricks displaced this symmetry and for this reason, perhaps Baudhāyana gave that unusual direction.

"Thus we have found that a new and larger square was used to be formed from another of smaller size by adding to it a portion in the form of a gnomon."

Tracing the early history of rational rectangle, Datta adds[48]: "We find it first in the Taittiriya Samhitā in connection with the Mahāvedi. It has then reappeared in the Kāthaka Samhitā, Maitrāyani Samhitā, Kapisthala Samhitā and Śatapātha Brāhmana. It should perhaps be noted that in these works only the sides (15, 36) have been expressly mentioned, but not the diagonal 39. This non-mention of the diagonal has led some modern writers to suspect if the property $15^2+36^2=39^2$ was at all known in the time of the Samhitās and Brāhmanas. But such a suspicion seems to be quite unwarranted. For even in later times, Baudhāyana has not mentioned the diagonal of the rational rectangles enumerated by him. From a thorough discussion of the point, Burk concludes: 'After all these, no doubt can exist regarding the fact that the rational right-angled triangle with perpendicular sides 15 and 36 was really known in the time of the Taittiriya Samhitā and the Śatapātha Brāhmana and was employed in the construction of the Śaumiki-vedi, as given in the Āpastamba Śulba sutra'[49]. Such was also the opinion of Cantor".[50]

After having become familiar with ancient Indian geometry, let us see how contemporary people in other lands fared in this regard.

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48. Datta B.B. *Science of the Śulbas* (1932), p. 138.
49. Burk ZDMG LV, p. 565.
50. Cantor Geschichte 1, p. 598.

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EGYPTIAN GEOMETRY

We are told by ancient historians that the Egyptians invented geometry and it was from them that the ancient Greeks learnt this branch of knowledge. The Egyptians surveyors, in ancient times, needed to know of different geometrical principles, as they had to measure areas of the fertile fields along the course of the river Nile, so as to get the appropriate amount of revenue due from the farmers. Masons in Egypt who built colossal pyramids with precisely cut stones in different shapes had also to be expert in geometrical knowledge, as were their counterparts in India who had to built altars.

Thus we see that the ancient Egyptians knew the methods of finding out the areas of rectangles, triangles and circles and the volumes of pyramids and cylinders from very ancient times.

MESOPOTAMIAN GEOMETRY

Mesopotamian geometry is less advanced as compared with that of the Egypt. Mesopotamians solved even their geometrical problems algebraically.

CHINESE GEOMETRY

Mohist writings of the eighth to the third century B.C., give definitions of a point and a line. Calculation of the areas and volumes of different figures is mentioned in various ancient Chinese texts.

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12

Vedic Medicine

We have no medical text as such with us that belongs to the early Vedic Age. However, the Vedic literature itself *i.e.* the Samhitās, Brāhmanas and Upanishads reveal a lot about the concepts and practice of medicine and the structure and functions of the human body. Our chief source in this regard is the Atharvaveda and its sutra the Kauśikā sutra. Besides that, the Rigveda, the Śatapātha Brāhmana and different Upanishads throw abundant light on the 'art of healing' of the Vedic Aryans,

To begin from the beginning, we will get acquainted with the Twin Aśvins who practised their healing art among the gods.

TWIN AŚVINS

In the Rigveda, Aśvins are called the divine physicians[1]. They had remedies against various diseases[2]. They could even ward off death.[3] Their worshipper attained old age with bright eye-sight and they brought him riches and lot of children.[4]

In the legendary account of their marvels, it is said that they restored youth to the old and debilitated body of the sage Chyavana and made him desirable to his wife again.[5] In the same way, they also invigorated aged Kali.[6] When the sage Rebha, after being stabbed, was hidden under the waters for ten days and

1. RV VIII 18.8.
2. RV VIII 22.10.
3. AV VII 53.1; T.B. III. 2.11.
4. RV I 116. 25; VIII 8.13.
5. RV I 116,10; Śatapātha Brahmana IV 1.5.21.
6. RV X 39.8.

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nights, they raised him up and revived him. They even delivered Vandanā from calamity and restored him to the light of the sun after raising him from a pit where he had been hidden away as dead.[7] They saved sage Atri Sapta-vadhri who along with his companions was plunged by a demon in the burning fires. They restored eye-sight to Rijrāśva who had been blinded by his father because he had killed his father's hundred and one sheep to quench the appetite of a she-wolf.[9] They provided an iron leg to Viśapāla whose own had been cut off in a battle.[9]

Providing an iron leg in place of an amputated one looks more like a genuine case rather than mythical account. In any case, it is certain that Vedic Indians in the Rigvedic period were familiar with providing a sustitute (prosthesis) limb.

ATHARVAVEDA

From the mythical Aśvins, we come down now to the magical formulae interspersed with empirical and even rational medical practice of the Atharvavedic period. The account of the healing art herein, is interesting as well as informative. There is hardly any reason for us to suppose that the Atharvavedic verses were composed at a time later than the Rigvedic, though of course, they seem to have been framed by people whose beliefs differed from those of the Rigvedic. Before we go into the contents of the Atharvaveda, let us see some basic facts about the Atharvaveda text that we have with us now.

According to the ancient tradition accepted by Śayana, its commentator, compilation of Atharvaveda was done in nine different collections, which differed slightly one from the other. These collections were called Paippalāda, Tānda, Mānda, Śaunakiya, Jajāla, Jalāda, Brāhmavāda, Deva-darśa and Charānavaidyā. Of these, only the Paippalāda and Śaunakiya collections are avail-

7. RV I 112.5 ; 116,11; 117.5; 118 ; X 39.8.
8. RV I 116.16; 117.17.18.
9. RV I 112.8

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able now. Paippalāda is still in manuscript form and has only partly been published. The other *i.e.*, Śaunakiya is the one that is available in print, and it is this that we commonly call as Atharva-veda. Saunakiya's Brāhmana is the Gopatha-Brāhmana and its five sutra texts are : (1) Kauśika (2) Vaitāna (3) Nakśatra kalpa (4) Angirasa kalpa and (5) Śānti kalpa. Of these sutra texts, Kauśika sutra is the oldest and the most important, as the other four depend on it. Commentaries were written on Kauśika sutra by Darila, Kesava, Bhadra, Rudra and many others in later times.

ĀYURVEDA : BRANCH OF ATHARVAVEDA

The existence of the Charāna-avaidyā collection of the Atharvaveda, which probably was compilation of the wandering medical practitioners, tells us that it probably was the predecessor of the Ātreya-Charaka school which came later; and it is essentially this branch which links Atharvaveda with the Āyurveda. From this it appears that Āyurveda—the science of prolonging life, is a branch of the Atharvaveda.

CONTENTS OF ATHARVAVEDA

Atharvaveda contains 6000 verses and about 1000 prose lines. These verses, more in the nature of charms, were uttered and utilized for various purposes. Briefly, they were used to have sharp intelligence, to attain virtues of a Brāhmachārin (celibate student), to possess cities, fortresses, kingdoms, villages, riches, food-grains, children, wives, cattle, horses, elephants, chariots etc., to induce peace and contentment among people, to frighten the enemy's elephants, to win a battle, to ward off all sorts of enemy's weapons, to cause enemy's army to run away and to protect one's own, to predict the result of a battle, to win over enemy's general and chiefs, to throw a charmed snare, sword and other weapons, to charm all musical instruments in war, to win back a lost city, to perform a coronation, to expiate for sin, to make cattle healthy, to protect crops, to make a new house auspicious, to get medici-

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nals for incurable diseases, to cure fever, cholera, diabetes, bleeding, epilepsy and possession of a person by demons or evil spirits, to cure diseases in which *vāyu*, *pitta*, and *kapha* is deranged, to cure heart diseases, jaundice, leprosy, consumption, dropsy, worm infestations in cows, horses and men, to have antidotes against all sorts of poisons, to cure diseases of head, ear, nose, throat, eyes, neck; for securing sons, for the welfare of the foetus and pregnant mother and easy delivery, stopping excessive rain, snow or drought, to win in debates, to win in gambling, to have success in trade, to prevent bad dreams, to remove unlucky effects of evil stars, to counteract the evil effect of enemy's charms, to secure long life, to perform ceremonies at birth, tonsure, marriage; to ward off earthquakes, eclipses of the sun and moon.

The above list for which the verses of the Atharvaveda were incanted, indicates the mode of thinking of the people of those times, their social needs, behaviour and environments. Besides that, it provides us with an insight into their art of healing. It clearly shows that these charms had lot of influence on the daily life of the common man, in a variety of circumstances. It also indicates that the priest doctors (bhiśajas) who chanted these verses were important members of the community and they were equally indispensible to the king as to the common man.

PRACTICE OF MEDICINE

It appears that during Atharvavedic times, there existed two types of healing arts and their adherents. The first type was that which predominantly depended upon incantations of magical verses to bring about cure. The second was that which did use the magical formulae but also used empirically or even rationally different herbals, their products and concoctions. Use of amulets was practised by both profusely.

Atharvaveda mentions that 'there were hundreds of medical practitioners and thousand of herbals, but that which could be achieved by a collective effect of them all, could be done singly by

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a chamed amulet'.[10] Also the one who binds the amulet is described as the best of all doctors.

It also appears that while in the earlier times priestly and magical practice was appreciated better, in the later times this was not so. The herbal doctor had developed, by then, confidence in the effectiveness of his drugs and it was this kind of practice which gained ground gradually and culminated in the establishment of the Āyurvedic medicine of the classical period.

There are many verses in the Atharvaveda which are devoted exclusively to praising the virtues of different plants. They also indicate their specific uses in specific disease conditions. This forms an interesting study and a full section has been devoted to it in a later part of the book, under the title of 'Medical Botany'.

CAUSE OF DISEASE

In the Atharvaveda, it is evident that committing a sin in the present or even past life, transgression of the normal divinely-prescribed course of life, disrespect to gods, and the witchcraft of the enemies, are some of the major factors that lead to different diseases. Different gods, singly or collectively, by themselves or through the agency of various demons, make man suffer for the wrongs he does. Hereditary diseases are caused as a result of the sins committed in the past life by the patient himself or by his parents.

Varuna, the cloud god could cause many diseases, but the one particularly attributed to him is dropsy *i.e.* the swelling up of the whole body. To get relief from this, the hymn chanted is:

> The golden chamber, king Varuna, is built in the waters!
> Thence the king that maintains the laws shall loosen all shackles:
>
> From every habitation (of thine), O king Varuna, from here

10. AV II 9.3

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do thou free us: If 'O waters, inviolable ones', if 'O Varuna' we have said, from this (sin) O Varuna, free us...

Loosen from us, O Varuna, all fetters, the uppermost, the nethermost and those imposed by Varuna ! Evil dreams and misfortune drive away from us: then may we go to the world of the pious.[11]

The procedure adopted, along with this chant, was that a hut was built at a point of land where the two rivers come together. The dropsical patient was placed in this hut. An offering was made while the prayer was recited, and the patient was washed with three bunches of grass, which had been dipped in water during the recitation.[12]

Rudra's special way of inflicting illness was to shoot arrows at the victims, thus causing acute pains. The remedy for this was the following prayer and incantation.

The arrow that Rudra did cast upon thee, into (thy) limbs and into thy heart, this here do we draw out away from thee.

From the hundred vessels which are distributed along thy limbs, from all of these do we exercise forth the poisons.

Adoration be to thee, O Rudra, as thou casteth (thy arrow) ; adoration to thee (arrow) when it has been placed upon (the bow) ; adoration to it as it is being hurled: adoration to it when it has fallen down.[13]

Takman was the god that caused fever and propitiating him was one of the methods to get rid of fever, as can be witnessed from the following verse:

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11. AV VII 83.
12. Kaušika sutra 32, 14-16.
13. AV VI. 90.

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When Agni having entered the waters, burned, where the (gods) who uphold the order (of the universe) rendered homage (to Agni), there, they say, is thy origin on high: do thou feel for us and spare us, O Takman:

Whether thou art flame, whether thou art heat, or whether from licking chips (of wood), thou hast arisen. Hrudu by name art thou, O god of the fiery, do thou feel for us, and spare us, O Takman:

To the cold Takman, and to the deliriously hot, the glowing, do I render homage. To him that returns on the morrow, to him that returns for two (successive) days, to the Takman that returns on the third day, homage shall be.[14]

The above verses are just a few examples. There are a lot many more in Atharvaveda in the same tune.

CONCEPT OF DISEASE

While many of the symptoms themselves were considered as diseases, as for example, dropsy, jaundice, retention of urine, cough etc., there were however, certain set of symptoms, in the presence of which in a patient, a diagnosis of a particular disease was made.

Writing about diseases in Āyurvedic medicine S.N. Das Gupta said[15], "My own conclusion is that at least some Atharvavedic people had thought of a three-fold classification of all diseases *viz.*, those produced by wind, those by water and those by fire or those that are dry and burning. This corresponds to the later classification of all diseases as being due to the three dośas, wind (vāyu), phlegm (kapha, sleśma) and bile (pitta)."

No doubt, we do find the seed of the Tridośa concept of Āyurvedic medicine in Atharvaveda.

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14. AV I 25.
15. Das Gupta S.N. *History of Indian Philosophy*, Vol. III, p 300.

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DISEASES

Fevers that occurred on different days or those that occurred continuously, diarrhoeas of varying severity, jaundice, dropsy, cough, consumption, different eye diseases, pustules, leprosy and other skin diseases, tumours, abscesses, retention of urine, epilepsy, madness etc., are some of the diseases that are frequently mentioned in the Atharvaveda. Addressing a dark coloured plant, the priest doctor chanted the following hymn to drive away the white spots in a case of leprosy:

> The leprosy and the gray spots drive away from here—may thy native colour settle upon thee—the white spots cause to fly away! The leprosy which has originated in the bones and that which has originated in the body and upon the skin, the white mark begotten of corruption, I have destroyed with my charm.[16]

In a mad and maniac patient who shouted wildly and who is 'bound and well-secured', Agni is invoked to calm down his mind which has been maddened by the sin of the gods or been robbed of sense by the demons (rakśasas). It is further prayed, 'May the Apsarās restore thee, may Indra, may Bhāga restore thee, may all the gods restore thee, that thou mayest be freed from madness.'[17]

TREATMENT

Methods of preventing ill-health and of treating diseases are naturally determined by the views held about the causative factors of the diseases. As committing sins, breaking the divine law and order, and witchcraft were considered as causative factors of different diseases in Vedic times, the treatment therefore, was to implore gods by incantations and also to counteract the witch-

16. AV I 23.
17. AV VI III.

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craft by the means that now look to us as magic and charms. Help of different herbs and their concoctions was sought, not only for internal use but also by wearing amulets made out of them.

Procedures adopted in treating different conditions and diseases were as follows:

To Attain Long Life: For the long life of a boy, the parents prayed thus:

> For thee alone, O (death from) old age, this (boy) shall grow up: the other hundred kinds of death shall not harm him! Like a provident mother in her lap Mitra shall befriend him, shall save him from misfortune! Lead this dear child to life and vigour, O Agni, Varuna and King Mitra! As a mother afford him protection, O Aditi, and all ye gods, that he may attain to old age![18]

To Counter a Curse: A curse was countered by a curse. The procedure was that a white lump of earth was given to a dog, an amulet was tied to the cursed person, an oblation was poured and faggots of a certain plant were laid on fire[19] and the following verse was chanted:

> The thousand-eyed curse having yoked his chariot come hither, seeking out him that curses me, as a wolf the house of him that owns sheep.
>
> Avoid us, O curse, as a burning fire (avoids) a lake! Strike here him that curses us, as the lightning of heaven the tree!
>
> He that shall curse us when we do not curse and he that shall curse us when we do curse, him do I hurl to death as a bone to a dog upon the ground.[20]

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18. AV II 28.
19. Kaušika sutra 48, 23-26.
20. AV VI 37.

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Such means are still employed in the Indian villages and even in the cities and a curse is removed or a demon who possesses a man, forced to run away by violent curse, as is witnessed in the above charm also. Even violent blows are given to the person who is possessed. It is explained by the priest that these blows do not hurt the patient; they only hurt the demon and make him run away.

To Treat Fever, Diarrhoea, Diabetes and Glandular Sores: A string made of (munja) grass was tied, the mud from a field or ant-hill was given for drinking, clarified butter was applied and holes of the anus and penus and the mouth of the sore were aerated with a leather bladder and the charm was chanted.[21]

To Treat Obstruction of Urine and Stool: The patient was made to drink either earth from a rat's hole, or a certain plant, curd, or saw-dust from old wood, or he was made to ride an elephant or a horse, or to throw an arrow; a fine iron needle was then passed through the urinal canal. The following verse was then chanted:

> I open your urinal path like a canal through which the waters rush. So may the urine come out with a whizzing sound.[22]

To Stop Bleeding: To check the flow of blood, as for example, after an injury, the incantation was:

> The maidens that go yonder, the veins, clothed in red garment, like sisters without a brother, bereft of strength, they shall stand still.[23]

At the bleeding spot a handful of street dust was applied or bandaged over.[24]

To Treat Jaundice: Magic treatment of jaundice consisted in transfering redness to the patient from the red objects and crea-

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21. AV I. 37.
22. AV I. 3.7.
23. AV I. 171.
24. Kauśika sutras 26, 10-13.

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tures, notably from a red bull. An elaborate ritual was developed to that end. An amulet consisting of a piece of bull's skin steeped in a cow's milk and anointed with the dregs of ghee was tied around his neck. He was to drink milk and eat prescribed foods, and the following hymn was recited:

> Up to the sun shall go thy heart-ache and thy jaundice: in the colour of the red bull do we envelop thee!
>
> We envelop thee in red tints, unto long life. May this person go unscathed and be free of yellow colour:
>
> The cows whose divinity is Rohini, they who, moreover, are (themselves) red (rohinih)—(in their) every form and every strength we do envelop thee.
>
> Into the parrots, into the ropanakas (thrush) do we put thy jaundice, and furthermore, into the haridrāvas (yellow wagtail) do we put thy jaundice.[25]

Herein it is prayed that the red colour of the sun and red cow may come to the patient's body and the yellow colour due to jaundice may go to birds of yellow colour.

Treating Worm Infestations: In a charm[26] against various diseases due to worms, the priest, while uttering the charm, holds street-dust in his left hand and presses it with his right hand and then throws it on the patient.

The worms are described as visible and invisible. Some of them are called *algandu* and others *śalūna.* They generate in the intestine, head and heels and go about through the body, and cannot be killed even with different kinds of herbs. They sometimes reside in the hills and forests, in herbs and animals, and they enter into the body through sores in our body and through various kinds of food and drinks.

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25. AV I 22.
26. AV II 31.

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In another charm against worms, the patient is given the juice of the twenty different kinds of roots.[27]

The above two hymns not only tell of an empirical or perhaps rational treatment but also give a very good description of the worms that infest the intestine and other parts of the body. The knowledge that they enter our body through food and drinks is highly creditable to the Atharvans.

Treating Fevers: Fevers of different kind seem to have been a common ailment. There were fevers whose onset was accompanied by cold, and others that started with a burning sensation all over the body. There were others that occurred every alternate day or by leaving two afebrile days in between. Some others were accompanied by jaundice, and others still by cough and consumption. There were those that occurred only in summer or in autumn and others that were perennial. Obviously in many diverse diseases, one of the main symptoms was fever.

A very interesting observation from epidemiological point of view, is that the regions named as Gandhāra, Mahāvrsā, Munjavān, and more particularly Balhika (Balkh), were regarded as 'homes' of the fevers.[28]

In the following hymn, fever (Takman) is propitiated as a god and is then rebuked and asked to run away and reside in the frog.

> Homage (be) to the deliriouly hot, the shaking, exciting, impetuous (Takman)! Homage to the cold (Takman), to him that in the past fulfilled desires! May (the Takman) that returns on the morrow, he that returns on two (successive) days, the impious one, pass into this frog.[29]

Treating Leprosy: A verse against the leprous white spots, describes application of an ointment made up of cow-dung and different herbs, on those white spots until they turn red.[30]

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27. AV 23.
28. AV V 11.
29. AV VII 116.
30. AV I 23.

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Against hereditary leprosy (that appeared in early childhood) an amulet consisting of (arjuna) wood, barley, sesamum and its flowers was tied on the patient.[31]

An other amulet for the same disease, contained horn of a deer.[32]

Treating Miscellaneous Diseases: For eye diseases, the patient was given different kinds of vegetable leaves fried in oil;[33] for increasing the growth of hair on the head, the hair was sprinkled with a decoction made up of different herbs;[34] a consumptive was asked to eat rotten fish;[35] for virility the root of a (Kapittha) tree boiled in milk was given for drinking; for poisoning due to some vegetable, the essence of a (Krmuka) tree was given for drinking.[36] For conception[37] in a woman and also for causing sterility[38], for conceiving a son[39], for preventing miscarriage[40] and for easy delivery[41] there are verses and formulae in the Atharvaveda.

Following is the verse for a sick man to chant himself.

> O Soma and Rudra, eject asunder the disease that has entered our household, drive far to a distance perdition; any committed sin put away from us. O Soma-and-Rudra, do ye put all these remedies in our bodies, untie, loosen from us what committed sin may be bound in our bodies.[42]

Treating Evil Omens: Evil omens that come in the form of pigeons, owls and black birds or evil dreams were warded off by

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31. AV II 9 & 10.
32. AV II 33.
33. AV VI 15.
34. AV VI 21.
35. AV III 2.
36. AV IV 6.
37. AV VI 81.
38. AV VII 35.
39. AV III 23;VI 11.
40. AV VI 17.
41. AV I 11.
42. AV VII 42.

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reciting verses and wearing amulets of pearl, shell etc. At night a person was thought to be very susceptible to being overpowered by evil spirits; so he prayed thus before going to bed:

> O Night, the earthly space hath been filled with the father's orderings, great, thou spreadest thyself to the seats of sky; bright darkness comes on. . .uninjured may we, O wide darksome night, attain thy further limit. . .Let no darksome night, attain thy further limit, no demon, (no) mischief-plotter master us; let no evil-plotter master us. . .[43]

FUNDAMENTAL POINTS OF TREATMENT

You would notice that the different Atharvavedic charms for treating diseases show certain fundamental similarities amongst them.

The foremost is the many-sided simultaneous approach to the diseases, *viz.* (1) to propitiate god, (2) to make a demon run away, (3) to use herbals as amulets, and as well (4) to make a medicine out of the herbals for internal administration. This clearly indicates that the clever priest-physicians of that era, were not sure of any one particular type of approach and they utilized all the different approaches that had proved effective in their experience at one time or another. Such an approach is not very much different from the one adopted in modern times by some of the physicians who add lot of medicinals—even more than half a dozen in a mixture, to be administered to a patient.

The second point in the practice of Atharvavedic medicine is that there is a lot of showmanship on the part of the physician. He prays, he threatens, he speaks of the tremendous powers of his medicinals and he even uses violent language and gestures. All this is to impress upon and to encourage the relations of the patient who are around—in the same way, as the physicians now-a-days say: 'There is nothing to worry, I have given the medicine

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43. AV XIX 47.

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and the patient will be well in a short time,' even though the physician knows very well that no improvement might occur in the condition of the patient.

Thirdly, in some of the verses, it is noticed that the priest-physician directly addresses the patient himself and tells him that as he is uttering the charm the disease-producing demon is running away; thereby preparing him psychologically to put up his best to fight the disease, as it is only a matter of time now that he will be cured.

Fourthly the use of a variety of herbals in various forms, alongwith chanting of their expected effects, clearly shows that the priest-physician had some idea of their action and their efficacy.

The next step was only to throw away the superstitious garb of the magic verse and to administer the medicinals only. Though modern physician has come a long way in this direction yet he has not completely lost the superstitious beliefs.

ANATOMY OF THE HUMAN BODY

There are many examples in the verses of the Atharvaveda and other Vedic texts that deal with anatomy of various parts of the human body. Some of the observations in this regard are rather rudimentary while others are in detail and show the acute sense of observation of the people.

The following hymn,[44] in a general way refers to different parts of the human body.

1. By whom were brought the two heals of a man (puruśa)? by whom was his flesh put together? by whom his two ankle joints, by whom his cunning fingers? by whom his apertures? by whom his (two) *uchlakhas* in the midst? who (put together) his footing.

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44. AV II 1-8.

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2. From what, now, did they make a man's two ankle joints below, his two knee-joints above? separating his two back-thighs, where forsooth, did they set him in? the two joints of his knees—who indeed understands that?

3. There is joined, fourfold, with closed ends, above the two knees, the pliant trunk; that the hips are, the thighs—who indeed produced that, by which the body became very firm?

4. How many gods (and) which were they, who gathered the breast, the neck-bones of man? how many disposed the two teats? who the two collar-bones? how many gathered the shoulder-bones? how many the ribs?

5. Who brought together his two arms, saying "he must perform heroism"? what god set on his two shoulders upon the body?

6. Who bored out the seven apertures in his head—these ears, the nostrils, the eyes, the mouth? in the might of whose conquest in many places quadrupeds (and) bipeds go their way.

7. Since in his jaws he put his ample tongue, then attached (to it) great voice: he rolls greatly on among existences, clothing himself in the waters who indeed understands that?

8. Which was that god who (produced) his brain, his forehead, his hindhead, who first his skull, who, having gathered a gathering in man's jaws, ascended to heaven?

The following verse, taken from Śatapātha Brāhmana, mentions instructions for construction of an altar that has the shape of a human figure with its different apertures. This shows that even

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an altar-maker was also supposed to possess a rudimentary anatomical knowledge.

9. To Trivrit (stoma) is its head, whence that (head) is threefold (tri-vrit)—skin, bone and brain.

10. The pankadaśa (fifteen-versed hymn-form) is the neck—joints, —for there are fourteen of these (joints), and the vital force is the fifteenth; hence by means of that (neck), though being small, man bears heavy burden: therefore the pankadaśa is the neck.

11. The saptadaśa (seventeen-versed hymn-form) is the chest; for there are eight 'gatru' on the one side, and eight on the other, and the chest itself is the seventeenth: therefore the saptadaśa (stoma) is the chest.

12. The ekavimsa (twenty-one-versed hymn-form) is the belly for inside the belly there are twenty 'Kuntapa', and the belly is the twenty-first, therefore the ekavimsa (stoma) is the belly.

13. The trinava (thrice-nine-versed hymn-form) is the two sides (parsva);—there are thirteen ribs (parsu) on the one side and thirteen on the other, and the sides make up the thrice ninth: therefore the trinava (stoma) is the two sides.

14. The trayastrimsa (thirty-three versed hymn-form) is the spine; for there are thirty-two 'Karukara' of that (spine) and the spine itself is the thirty-third: therefore the trayastrimsa (stoma) is the spine.[45]

TOTAL NUMBER OF BONES

In an ingenious way, an hymn of Śatapātha Brāhmana men-

45. SB XII 2.4. 9-14.

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tions the total number of bones in the human body, as thought of during those days. The relevant stanzas are as follows:

3. And there are three hundred and sixty nights in a year, and three hundred and sixty bones in man, and these (two) now are one and the same;—there are three hundred and sixty days in the year, and three hundred and sixty parts of marrow in man, and these (two) now are one and the same.

4. And there are seven hundred and twenty days and nights in the year and seven hundred and twenty bones and parts of marrow in man and these (two) now are one and the same.[16]

These 360 bones are as follows :

(1) Heals, two in two feet, (2) ankle bones-two, (3) digits—in pleural number, (4) metacarpal and metatarsal bones of hands and feet, (5) base (pratishtha), (6) the knee caps-two, (7) the knee joints, (8) the shanks-two, (9) the pelvic cavity, (10) the thigh bones-two (11) the breast bones, (12) the windpipe–in the pleural, (13) the breast–two, (14) the shoulder–blade-two, (15) the shoulder-bones-pleural, (16) the back bones-pleural, (17) the collar-bones-two, (18) the brow, (19) the central facial bone, (20) the pile of the jaw, (21) the cranium with temples.

Śatapātha Brāhmana mentions 26 ribs (parśus) which are fastened at either end to the thoracic vertebra at the back and anteriorly to the costal cartilages[17]. The vertebral column has three subdivisions: (1) the cervical (2) thoracic and (3) the lumber[18].

INTERNAL ORGANS

Heart (Hrdya) : Ideas about the structure and functions of

46. SB XII 3.2. 3-4.
47. SB XII 2.4.13 VIII 6.2.8-10.
48. SB XII 2.4.12.14.

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the heart, look to be fairly rudimentary during the Samhitā period. In a prayer, it is said 'O Mitra and Varuna, take away the thinking (chitt) power from the heart'[49]. Heart is said to have the shape of a lotus with nine openings in it.[50]

Some of the Upanishads, describe heart rather well. It is said to be made up of flesh with a net-work structure.[51] It is like the wheel of a chariot, the spokes of which are like arteries emanating from it, the number of which is variously described as 101[52] and 72000[53] (alongwith the sub-branches), which pass out from the heart through the pericardium, with which the heart is covered.[54]

Its weight is described to be 8 palas (870 grams) in Gārbha Upanishad.[55]

NĀDIS, DHAMANIS AND SIRAS

Let us see whether in the Vedic literature, there are references to distinguish different sorts of channels carrying different fluids in the human body.

Brihadrānyaka Upanishad describes that there is the finest essence of food juice inside the cavity of the heart. It is this essence which by penetrating into the finest nādis serves to support the body. Heart is surrounded by a net-work of nādis and from it (food essence) rushes upwards through the extremely fine hita nādis.[56] On the other hand, in the same Upanishad, it is stated that the hita nādis of the heart are as fine as a thousandth part of a hair and they carry white, blue, yellow and green liquids. Chhāndogya Upanishad states that 101 nādis proceed from the

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49. AV III 26.6.
50. AV X 8.43.
51. Brihadāranyaka Upanishad IV 2.4.
52. Katha Upanishad II 3. 16 ; Chhāndogya Upanishad VII 6.6.
53. Brihadāranyaka Upanishad II 2.19.
54. Vajāsaneyi Samhitā 39.10.
55. Roy Mira, Anatomy in the Vedic Literature I.J. His. Sc. Vol. 2, May, 1967, p. 40.
56. Brihadāranyaka Upanishad IV 2.3.

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heart.[57] Māndukya Upanishad[58] also speaks in the same tune when it states that like spokes in a wheel the nādis are connected to the heart. Praśna Upanishad, however, says about nādis differently. It says that vyana vayu (sort of air) flows through 100 nādis connected with the heart. Here by nādi it perhaps, means the blood vessel but has found it empty or containing air only. Maitrayani Upanishad mentions suśma nādi proceeding upwards towards the head through which flow prāna (again a sort of air).

Atharvaveda in a reference states two nādis called gavinyān which carry urine from the kidneys to the bladder.[59]

Then word dhamani[60] and śira have also been used, on different occasions to denote the same meaning as nādi and it is certainly difficult to assign a particular specific and different meaning to each of these terms. No doubt in certain references the term dhamani has been used to denote a larger channel than the other two.

There is no basis at all to suppose that the Vedic people could distinguish an artery from a vein.

But more important is the fact that the people in Atharvavedic times made observations, perhaps on the living and certainly on the dead bodies, and looked for the smallest channels of the body and tried to recognize their contents as well. That these contents moved about was also recognized, though there is no basis to suppose that Atharvavedic people understood circulation of the blood in the body as we understand it now. In a verse in Atharvaveda it is stated, 'who stored in him floods turned in all directions moving diverse and formed to flow in rivers, quick, rosy, red and copper dark, running all ways in a man upward and downward[61].

Others organs mentioned in the Atharvaveda are the lungs? (kloma), bronchi, the gall-bladder, the kidneys, liver, spleen,

57. Chhandogya Upanishad VIII 6.6.
58. Māndukya Upanishad II 2.6.
59. AV I 36.
60. AV VI 90 5.
61. AV X 2.11.

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stomach, intestines, colon, rectum, urinary bladder etc. Semen was considered as 'the thread of life.'[62]

From the above account, it would become clear that without seeing the open human body (for whatever purpose), they would not have known and spoken of some of the detailled description of it. Of course about dissection of the horse's body, explicit mention has been made in Rigveda[63] and Yajurveda,[64] which describe different parts of its body.

CONCEPT OF THE HUMAN BODY[65]

Human body, through the ages in India, has been considered as a manifestation of the divine substance and energy. The principal forces and faculties which abide in the body, giving it life and supporting its processes, are microcosmic counterparts of the powers which pervade the cosmic body, the universe.

Such correlation or correspondence of entities, cosmic and human, is witnessed in a variety of myths and speculations.

One such example is found in the Puruśa sukta of Rigveda. This hymn deals with the origin of the universe from the body of a primeval being, the First Great Man (puruśa). According to it, the gods, in the beginning of time, took this primordial man and sacrificed him. As they divided the victim, his head became heaven, his feet earth, his ears became space, his eyes the sun, his breath the wind-god and so on.

Another Vedic source describes that at the dawn of creation, 'the divine guardians of the world spheres' (loka pāla), emanated from the body of puruśa and entered as sense-faculties and life-forces of the human body. Fire became speech and entered the mouth, wind became breath and entered the nostrils, the sun became sight and entered the eyes, the quarters of space became

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62. AV X 2.17.
63. RV I 162.13.
64. Taittiriya Samhitā V 3.6.
65. Zimmer, H.R. Hindu Medicine, Baltimore 1948, pp. 109, 114-119.

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hearing and entered the ears, plants and trees became hair and entered the skin, the moon became mind and entered the heart, death became breathing down (apāna) and entered the navel, waters became semen and entered the male organ.

The following hymn of Athavaveda describes this process more elaborately:

——When (in the beginning of time) the Divine Craftsman, drilled the apertures (which are the outlets for the sense faculties and vital processes of the human body), the gods took the mortal for their house and entered man.

Sleep, forsooth, weariness, bane; the divinities evil by name; old-age, baldness, hoariness entered the body, one after another.

Theft, ill-doing, wickedness, truth, sacrifice, and great fame; strength, and valor and force entered the body one after another.

Luck and ill-luck, increase and waning, liberalities and illiberalities whatever there are, and all hungers and thirsts entered the body, one after another.

Blaming and not-blaming and what is 'Well' and 'No', what is known and unknown, and what else is to be taught; entered the body, one after another.

. . .delights, joys, enjoyments,. . .laughing, dancing,. . .addressing and prating; breathing forward and breathing downward; sight and hearing; the indestructible and destruction; breathing asunder and breathing upward, speech, mind, entered the body, one after another.

. . .Whatever waters there are and whatever divinities; the Lordly Power (of the Highest Being: Viraj) together with Brahman (the supreme essence); Brahman entered the body; the Lord-Creator dwells in the body (as the generative principle).

The sun took possession of the eye, wind of the breath, each one as his own share (while the other forces of nature found their places in the organs and functions of the human body which correspond to them).

Then the divinities bestowed man's other (mortal) self (which is consumed on the funeral pyre) upon the Fire god...

Therefore, indeed one who knows man thinks 'this is Brahman'

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(the divine principle manifesting itself in all forms and activities of the universe), for all divinities have their abode in man, as cows in a cow-pen.

PRĀNA (VITAL BREATH)

There is a passage in Praśna Upanished, as follows:

'Then Kausalya the son of Aśvala asked Pippalāda: Sir, whence is this prāna born? How does it come into this body? How does it abide in the body after it has divided itself? How does it depart? How does it support the external and how the internal?

'To him the teacher replied, you are asking difficult questions; you must be exceedingly devoted to Brahma. Therefore I will answer you.'[67]

The word prāna is not breath. It is much more than that, as we shall see presently.

There is a lengthy hymn in Atharvaveda which is chanted as a prayer by a person to his own life-breath (prāna) to make sure of its continued beneficient presence within himself. This hymn reveals the meaning, of prāna, as understood during the Vedic period. It reads as follows:[68]

1. Adoration to breath.
   under whose power is this All,
   who has become the lord of All,
   in whom All stand grounded.

2. Adoration, breath, to thee, the roarer,
   thee, thunder,
   Adoration, to thee, Breath, the lightning,
   Adoration, Breath to thee, thou raining one.

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67. Praśna Upanishad III 1.2.

68. Translation and comments by Zimmer H.R. (1948) Hindu Medicine. Baltimore, pp. 119-132.

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3. When Breath with thunder roars upon the herbs,
impregnated, they conceive
fruits in their wombs,
then many are they born, and all around.

4. When Breath, the season having come,
roars at the herbs
then whatever is upon the earth,
all is delighted.

5. When Breath has rained,
upon the great earth, with rain,
then cattle are delighted,
"Verily greatness will there be for us".

6. The herbs being rained on,
had a talk with Breath;
Our life-length (ayu), verily, is by thee made long,
and all of us has thou made fragrant !"

In the above verses, the devotee in paying homage to his own life breath (prāna), first celebrates it as the cosmic life-principle, the Lord of all, whose enlivening forces manifest themselves most impressively at the rainy season; hence the reference to rain, thunder and lightning that quicken vegetation and cattle and rescue nature from the merciless summer heat. The rain bearing monsoon wind, thought of as carrying on its wings the refreshing fluid of the life-giving celestial waters, is the most potent and auspicious manifestation of the life-breath of the universe.

7. Adoration be to thee, who comes,
to thee, who goes away,
adoration, Breath, to thee who stands,
also to thee who sits, be adoration.

8. Breath, adoration to thee, breathing forth,
adoration to thee, breathing down.

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adoration to thee, turned away,
adoration to thee, turned back;
this adoration to thee, in all forms of thee.

9. Breath, that body dear to thee;
that body even dearer,
thy healing force, as well,
bestow thou it upon us unto life.

From the macrocosmic aspect of breath, the hymn turns to its activity in man. All its movements and expressions are worthy of worship (7.8): its flowing in and out; its turning away, and its returning (that is the same life bearing fluid, essential substance that moves downward and forward seems evident). There is a healing force (bheśaja), a curative element or medicine in breath (9), if it is properly worshipped and attended to. This remark refers to the breathing exercises which, apart from special yoga technique and training, form part of the daily devotional practice of the Hindu at dawn and at dusk. The solemn rhythmical monotony of the incantation suggests that its recital may have been accompanied by a regulated rhythm of breathing, apt to evoke the presence and to propitiate the good will of Breath.

10. Breath clothes the beings,
as a father a beloved son;
Breath is Lord of All
that breathes and breathes not.

11. Breath is death, Breath is fever,
Breath the gods do wait upon
Breath may carry him who speaks truth
into the highest world.

Breath maintains beings as a father does a son. But since it is the paramount principle of nature, Breath incorporates the negative as well as the positive aspects of existence. In this res-

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pect it ranks with the highest Hindu divinities (Vishnu, Śiva, the Goddess), who, representing the universal source and law of life, incorporate the destructive forces alongwith the creative and maintaining principle, and display wrathful and terrifying attitude (ghoramūrti) as well as one that is benign and merciful (sundāramūrti). Breath can appear as deadly sickness as destructive fever (takman); nay, it is death incarnate. As such it is the carreir and guide of the soul in the hour of death. The immortal Breath, in abandoning the body, gathers together the sensual and psychic forces of 'him who speaks truth,' of the initiate of the secret wisdom, and carries his soul, to the highest heaven of the gods.

12. Breath is She, the power-Widely-Ruling,
Breath is she, the power-that-Commands;
Breath all wait upon, breath is Sun and Moon;
Breath they call the Lord-and-Creator of Beings.

13. Breathing forth, Breathing down are rice and barley;
Breath is called the draft-ox, drawing;
Breathing forth is set in barley,
Breathing down, called rice.

14. Man breathes down, breathes forth,
within the womb;
when thou quickenest O Breath,
then he is born again.

Life breath is to be regarded as the unity of antagonistic principles. In cosmogony, it manifests itself as 'Viraj' (12) that is 'as the widely ruling power', which is the first female principle to evolve from the Supreme being as his daughter, mate or feminine aspect. She, the primal cosmic 'Cow' is maternal nature, bringing forth the universe and representing its substance. At the same time prāna is primeval energy, enlivening all beings, and urging them by her commands on to their respective activities. Moreover in maintaining the universal life-process, life-breath manifests

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itself as Moon and Sun, that is as the moistening, nourishing principle which is 'food' and 'feeder' for gods and creatures and as the fierce, devouring power of fire in its celestial form which matures and withers the organism. Such a union of opposites, in the case of the microcosmic life-breath, is observed in its twofold movement, breathing forth and breathing down; and in the two principal kinds of sustaining food stuff, rice and barley (13, 14); it is prāna that enables man to live while in the womb, and to be reborn as son and *alter ego* once he is expelled from the womb by the pneumatic pressure of the mother's life-breath:

15. Breath they call Him-that-Swells-in-the womb,
Breath is called wind,
in breath, what has been, what will be
in Breath does all stand grounded.

16. They of the Atharvans; of the Angirases,
they of the gods, those born of men, as well,
herbs bring forth herbs
when thou, O Breath, doest quicken them.

17. When Breath has rained
on the great earth with rain,
herbs are born forth,
whatever plants there are, are born

18. Who knows this of thee, Breath,
he, grounded in whom thou standest,
to him shall all bring tribute
in younder highest world

19. Breath, as these beings all
bring tribute to thee,
so shall they bring him tribute
Who hears thee, thou well-heard-of-one !

The hymn then dwells again on the macrocosmic aspects of

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life-breath in the form of the fire of lightning, the divine babe that grows in the watery womb of the motherly clouds (mātariśvan) (15); of wind (15), and rain (17), and the vegetation stirred into existence by the cosmic prāna (17). Thus the incantation returns to the idea from which it started; in closing the cycle it announces the reward which is in store for the initiated who becomes aware of the power of breath and worships all its aspects, revering its very sound as perceived in its ceaseless rhythmical flow both in his own organism and in the universal body (18.19).

20. As yet unborn, he moves within divinities,
having come into being, having now become,
so is he born again, so having been,
he enters forcefully what is to be,
what will be father into son.

21. The Swan in rising draws not one foot from the waters.
Verily, if he should draw that out,
there would be no today, no tomorrow,
night, or nor day, not ever would it dawn.

22. On eight wheels it rools, with single rim,
with thousand syllables, forth forward, down behind
with this half has it brought forth all existence—
what that half is, what is the sign of it?

23. Who lords it over all, this that stirs,
born of all birth,
with a quick bow among the inexhaustible ones,
as such be adoration, Breath, to thee.

24. Who lords it over this, all this that stirs,
of every kind of birth,
unwearying and wise by Brahman
may breath stand by me.

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25. Upright among the sleeping, wakeful
never lies he prone,
no one so ever has heard of his
sleeping among the sleeping.

26. O Breath, turn not away from me,
never another-shalt thou be than!
like the Babe-of-the-Waters,
I bind thee to me unto life, O Breath!

In the above seven stanzas, the hymn delves again into the secret nature of prāna as the supreme principle in man and the universe, enlarging on its diverse aspects.

Prāna excels over the other divine powers which animate the human body as sense faculties and active agents; for prāna alone partaking of the wisdom of Brahma, remains unwearied and ceaselessly active, while the others tire and lie down, when man falls asleep (23-25).

Its paramount strength is extolled in terms of solar symbolism; it is compared in power to the eight-wheeled chariot of the sun, to the wheel of the sun-disk with its single rim; like the solar force worshipped elsewhere as representing the supreme principle, prāna is of a twofold character, being intra-mundane, and supra-mundane at once (22); like everything else it manifests itself with one half of its strength, while the other half of its essence abides beyond, inscrutable, not to be ascertained by any sign, in the transcendent sphere, wherefrom the universe proceeds.

In this twofold character, prāna is comparable to the wild swan (hamsa), another symbol of the sun (21). The swan is thought of as a miraculous creature. It is superior to other aquatic birds living on lakes and ponds and bound to their natural habitat, in that it can separate itself from the watery realm in which it is at home. Withdrawing both legs from the liquid element, it soars into the upper reaches of the atmosphere to cover wide distances in its wandering flights, it is as much at home in the ethereal realm above as in the waters below. The swan is the

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homeless, free wanderer between the upper and the lower spheres, the life-giving waters of earthly existence and the ether, the realm of pure formlessness, the infinite.

Like the swan, prāna as the life-giving principle is intra-mundane, dwelling in the universe and its being, while as the supernal source of universal energy it is supramundane. But unlike the bird with which it is compared, the swan like prāna never withdraws both its feet from the watery realm of the macrocosm and microcosm which it is animating; should it do so, life would cease to exist.

The very term for swan 'hamsa' in post-Vedic tradition, is supposed to express in its two syllables the activity of inhaling and exhaling; it is onomatopoeic: 'ham' describes the sound of inhaling, 'sa' of exhaling, breath. Prāna is the inner swan, which through the unceasing song of its very name, brings about the two-fold activity of the essential breathing down and breathing forth. The outgoing movement, breathing forth, is compared in the hymn to the swan's withdrawing one foot from the body, the realm below, which evolved from the primal waters. But the virtue of the breath swan, most worthy of wonder, lies in its keeping 'one leg in the water'; it does not withdraw from the body though it proceeds out of the body with every exhaling movement. Miraculously, prāna abides with man, though, like the wandering swan, it is free to depart at any moment from the human body and to return to the etheral sphere, its other home. When in 'breathing forth' it withdraws one foot for a while, prāna seems ready to leave the realm below, and to soar up far away into the vast upper space, then, however, in 'breathing downward', it again drops its foot back into the watery realm of earthly existence.

Life-breath, man's inner swan, remains faithful to the abode it has chosen in man's body; through its incessant two-fold movement the swan re-establishes the continuity of its participation in both spheres, the inner and the outer, the higher and the lower. Prāna plays the role of the life-giving guest of the human body, as it were, deigning to stay on and to bestow its beneficient presence for a full life-time; if properly honoured, it never withdraws

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completely though free to do so, communing in a ceaseless rhythm with the sphere beyond the organism, it proceeds from its apertures with one of its limbs.

The aforesaid description of the concept of diseases, practice of medicine and treatment, anatomical and physiological views, prevailing in Vedic times, clearly indicates that the art of healing of that era was by no means primitive. In a nut-shell, it can be said that it carried the seed that blossomed forth into a full fledged tree, in the later classical period of Indian medicine.

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13

Medical Botany and Agriculture

Plants and their products formed part and parcel of the practice of medicine in Vedic times. Quite often their use in different diseases appears to be rational *i.e.*, based upon proper understanding of their action and effect, but more often it is just empirical *i.e.*, based only upon the previous experience of their having been found useful in similar conditions.

Different plant products were not only taken internally or applied externally but also amulets made out of them were worn. Vedic Aryans were familiar with dozens, even hundreds of different plants that were useful either singly or in combination with others, in different disease states. They revered them, propitiated them and also actively cultivated them so that they may be available abundantly.

In the following hymn[1] of the Rigveda, the physician (bhiśaja) praises such medicinal plants, ascribes a hundred-and-seven virtues to them and requests them to help him cure the patient.

1. These herbs, the first-born of the gods,
three ages of the world ago,
these will I worship in my thought
the hundred-and-seven virtues of these
(with new) tawny (sprouts).

2. Hundred, O mothers are your virtues,
and thousand your shoots,
ye, of hundred potencies, then,
make me hale this man.

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1. RV X. 97. translated by Zimmer H.R.

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3. Rejoicing, herbs, respond,
Ye with flowers, ye with shoots,
like mares, winning the race
eager, the plants to ferry over to the side of safety.

4. Herbs:—thus I address you, mothers, goddess,
may I win horse, cow, clothes,
. . .thy life-spirit (ātman), O man!

5. In the Aśvattha (tree) your seat,
your abode made in its leaf
ye like milking cows would be
when you better me this man!

6. With whomever the herbs have come together
like kindly chiefs unto the gathering,
that Brāhmana is called a 'healer' (bhiśaja),
a demon-killer, a plague-dispeller.

7. The rich in mare-like waters, the rich in Soma,
the invigorating, the one excelling in strength:
all herbs found I for this man
to free him from harm.

8. Like cows from the cow-pen,
stream forth the virtues of the herbs,
eager to secure rich fee (for me),
(for thee) thy life-spirit (ātman), O man!

9. Weal-working is your mother's name,
hence you are woe-expellers.
Winged streams are you:
you expel what ails.

10. Over all enclosures they have climbed
like a thief into the cow-pen.
The herbs have driven away
all defects of the body whatever.

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11. Since, strength-imparting, I hold
in my hand these herbs,
the life-spirit (ātman) of consumption vanishes,
as if in front of Him who seizes the life-soul
(Yama, King Death).

12. Whom, herbs, you crawl along,
limb by limb, joint by joint,
from him consumption you divide asunder,
as, located-at-the-center,
the mighty (king divides asunder
the ring of neighbour kings who
prey upon his realm).

13. Fly away, consumption, together with the jay,
with the blue jay,
with the blast of the wind
with the storm, vanish!

14. One of ye help the other,
one to the other be helpful,
ye all, of one consent,
help onward this my spell.

15. Those with fruit, those without fruit,
those flowerless and those with flowers,
impelled by the Lord of Magic Spells (Brihaspati),
may they deliver us from ill.

16. May they deliver me from imprecation
and from (the dropsy) that-comes-from Varuna,
and from the Tamer's fetterlock (sickness unto death),
from all god-sent diseases.

17. Flying down from heaven the herbs spake:
Whom, alive, we reach,
that man does not perish.

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18. Whatever herbs there are in Soma's kingdom,
the many, wise a hundred-wise.
Of these thou are the best
ready to desire, weal to the heart.

19. Whatever herbs ye be in Soma's kingdom,
spreading earth-wide,
impelled by the Lord of Magic Spells,
lay your strength together in this herb.

20. May he not come to harm who digs you,
nor he, for whom I dig you;
our two-footed, our four-footed
all uninjured be.

21. Whatever plants hearken to this spell,
and those gone out of reach,
all flocking here together,
shall give their strength together in this herb.

22. The herbs consult with Soma, with their King:
'For whom a Brāhmana works a charm
him O King, we ferry over to the side of safety'.

23. Thou art the best, O herb,
the trees to thee are servants;
Be subservient unto us,
He, who seeks to do us harm.

Commenting upon this hymn, Zimmer says[2] that in this hymn, all existing herbs are invoked to lend aid: 'the many, wise a hundred-wise' (18), 'with hundred and seven virtues' (1), and 'of hundred potencies' (2), 'those within reach, and those out of reach of the healing magician' (21).

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2. Zimmer H.R. (1948) *Hindu Medicine*, Baltimore, p. 26.

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All the forces of the vegetable kingdom are blended into a powerful arcanum (21), to conquer Consumption (11-13), by which term it is not quite certain what is meant. Neither is the patent decline of the patient's life-strength clearly diagnosed with regard to its origin.

The efficacy of the divine herbs, when duly recognized, brought together and put to use; is beyond question. They are propitiated by extolling their origin, kinship and virtues (1,2,3,5,9,17,22). Their friendly, 'motherly' character is insisted upon to preclude any harmful reactions due to their ambivalent nature (2,4); they are appeased for being disturbed and uprooted (20), and implored to protect the inhabitants and the animals of the household and of the village (20).

An arcanum is made up of their combined forces (14,15,19,21), which is supposed to cure all kind of diseases (16), and to ferry the sick man 'over to the side of safety' out of reach of Death (3,16).

A particular and rather striking element of this hymn is its insisting on the close relation between the expected healing effect of the treatment and the doctor's 'rich fee' (8), consisting of 'horse, cow, clothes' (4). The magic procedure assures the patient's recovery, in as much as the latter bears in mind the ample reward that he owes to the healing magician. The fee, the physician expects, is regarded as reciprocal to the effectiveness of the treatment and even as generating it. The considerable size of the expected salary is 'rubbed in'. Such a business-like aspect of the relation between doctor and patient has its therapeutical value. The emphasis on the costliness of the treatment is intended to reflect the high capacity of the medical authority called upon to treat the case, and the efficacy of the means at his disposal as well. This is expected to exert a salutary psychological effect through its appeal to the 'sacred egotism' of the ailing individual, his monetary instinct; it is not intended as a distracting reminder of the bill to be footed, but is meant to act as an incentive, appealing to the patient's instinct for co-operation and recovery. High fees invariably inspire confidence in the practi-

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tioner's skill and the efficacy of the medical tradition; they stimulate the lingering or malingering patient to mobilize whatever hidden energies are within him, to pass the crisis and get over his illness.

For the same purpose, the secret knowledge of the medical magician is emphasized: he knows that what council the divine herbs hold among themselves and how they pledge their assistance to the Brāhmana doctor (22), the authentic healer (6), before their king Soma. An important asset of the Brahmana magician in dealing with these disease-demons is his ability to league himself with the divine healing forces. The hymn points out this privileged position of his by referring to the Lord of Magic Spells (Brihaspati, Brāhmanaspati) as his powerful ally (15,19). Brihaspati is the foremost of the Angirases, the ancestors of the oldest priest-families; he attained divine rank through acting as house priest, and arch-magician to Indra and the gods. He is, by very name, the 'master' (pati) of the innermost soul-force which works magic through communion with the divine.

The effective steps the doctor takes to dispel consumption from the patient's body are reflected in detail in the course of the hymn.

First, he concentrates on the divine powers of the herbs, and praising their origin and virtues, he convokes them, urging them thither (1-7). The mere physical presence of the vegetable drug-stuffs, combined into the arcanum to be administered, is evidently far from sufficient to secure the effect desired. The spiritual energy of the herbs, their good-will, co-operation and eagerness to help must be secured. Their personalities like those of human beings, must be activated in order to render their co-operation effective.

Next, they are enjoined to go to work, presumably through the arcanum administered as a potion (8), and the actual working of their qualities and strength is stated and described (9). Then, the definite success of this internal treatment is emphatically asserted: 'the herbs have driven away all defects of the body whatever'. Herewith the internal treatment apparently reaches its culmination.

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The following long hymn in the Atharvaveda[3] is intended to be chanted when out of different plants, a medicine is prepared for a patient suffering from consumption (yakshma).

1. These that are tawny and that are bright,
the red and the spotted,
the swarthy, the black herbs,
all do we conjure hither.

2. Let them save this man
from consumption sent-by-the-gods,
these plants, fathered by Heaven, mothered by Earth,
whose root is the primal cosmic ocean.

3. The divine herbs in the beginning were the primal waters;
they have made depart from thee, from every limb,
thy sin-born consumption.

4. The spreading, the bushy, the one-spathed,
the extending herbs, I conjure hither.
Those with shoots, those with joints, those with
spreading branches,
I call for thee the plants that are of all gods,
mighty, life-giving unto man.

5. Whatever power is yours, ye powerful ones,
whatever velor and strength is yours,
therewith free ye this man from this consumption,
O herbs, Now do I make a remedy.

6. The lively, by-no-means-harming, living herb,
the non-obstructing, upward-leading,
nourishing flower, rich in sweets,
do I call hither,
to make this man free from harm.

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3. AV VIII. 7. (translated by Zimmer H.R. 1948).

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7. Hither shall come the forethoughtful ones,
the allies of my spell,
that we may safely ferry over this man from distress.

8. Food of Fire, from the womb of Waters,
growing up renewed, firmly rooted, named a
thousand names,
be they remedial in being brought.

9. With Avakā (Blyxa octandra Rich) as their hull
with the waters as their nature
May the sharp-horned herbs rend distress asunder.

10. These that release, dispel varuna (*i.e.*, dropsy),
the mighty, the poison-destroyers,
the swelling-dispellers as well,
the spoilers of witchcraft,
may these herbs come hither!

11. The purchased, and praised, most powerful plants,
May they protect in this village
Cow, horse, man and beast.

12. Rich in sweets the root, rich in sweets the tip,
rich in sweets has grown the middle of these plants:
rich in sweets the leaves, rich in sweets the flowers of these,
partaking of honey, a drink of the elixir of Immortal life
(amrita).
May they milk forth melted butter, food,
and first of all, milk.

13. How many and whatsoever be these herbs upon the earth
May that, the thousand leafed,
release me from death, from peril.

14. May the tigerish amulet of plants,
protecting, guarding against imprecations,
smite far from us diseases and all demons.

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15. As at the lion's roar,
they start with fear,
as at fire, they start fearing the herbs brought hither;
May consumption of kine, of men, be gone,
driven out by the plants, beyond the navigable streams.

16. Herbs, released from the Fire who-dwell-with-all
men (Vaisvanara),
go ye stretching over the earth,
ye whose king is the forest-tree.

17. Those herbs, related to the Angirases (the semidivine first
Brāhmanas),
which grow on mountains and plains,
may they be rich in milk, propitious,
weal to our heart.

18. Those plants I wot, those with the eye I see,
the unknown and the ones we know of,
and these in which we wit the virtues brought together.

19. May all herbs together note my spell
that we may safely ferry over this man out of distress.

20. The Aśvattha (tree, Ficus religiosus Indica), the
Darba (-grass, Sacchorum Cylindricum),
Soma, the King of plants, oblation, the immortal dish,
rice and remedial barley, ye twain immortal
sons of Heaven,

21. Rise ye up;- it thunder and roars at (you), O herbs,
When Parjānya (the god of rain) favours you with seed,
O ye children of the spotted Cow (the earth).

22. Of this divine elixir of immortal life (amrita),
we make this man drink strength;
now I do make a remedy,
that he come to a hundred years.

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23. That plant the boar knows,
that remedial herb the mongoose knows,
(the genii of the amrita-containing
moon cup, guardians of the vegetative lunar cycle),
those I call to his aid.

24. Whatsoever herbs, related to the Angirases, the eagles,
whatsoever divine ones the bees (?) know.
Whatsoever the birds, the swans know, and all winged ones,

25. Of however many herbs the inviolable kine eat,
Of however many the goats and sheep,
May all these herbs, brought hither,
extend protection unto thee.

26. In however many herbs the human physicians find a remedy,
So many, all remedial, do I bring unto thee.

27. Those rich in flowers, rich in shoots
rich in fruits, these fruitless ones as well,
like mothers assembled, let them yield milk
upto this man for freedom from harm.

28. I have snatched thee away from the Him-with-the five-stings,
and from Him-with-the-ten-stings as well,
also from the fetterlook of the Tamer (Yama, King Death) from all sickness sent by the gods (in retribution for offences).

Commenting upon the above hymn, Zimmer writes[4]: 'Consumption, to be expelled from the patient's body through

4. Zimmer HR (1948) *Hindu Medicine*, Baltimore, p. 15.

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the magic ritual of which this hymn forms the oral part, is regarded as extremely powerful, since the whole array of the healing powers the vegetable kingdom has in store, is conjured to fight it off. The term 'consumption', used in a rather vague but very comprehensive way, somehow seems to cover an anonymous collection of malignant forces which cause the ailing person to languish. Accordingly, the doctor-magician calls upon the herbs and plants to furnish all possible aid.

The underlying idea seems to be that there are, strictly speaking, no herbs whatsoever that are destitute of healing power. All of them have a specific character, particular virtues of their own, which are manifested in many forms, colours, the places where they are found, their uses, their effectiveness and so forth; accordingly all these various forces may be brought into play to prevent the decline and loss of life-power, if properly propitiated and harnessed to the physician's efforts.

The gathering together of all plants and herbs existing on earth by the enumeration and description of their characteristics and forms (1,4,8,13,27), and the full treasury of healing forces in vegetation, called by 'a thousand names' (8), is to be brought to the aid of the patient. Insofar as they form part of the physician's wisdom, they are all brought together and blended into an all-powerful arcanum; but there are many which are unknown to the doctor-herbalist (bhiśaja) (13, 18), nor are they listed by medical tradition; however, they are well-known to other beings, domestic animals and beasts of the wilderness, birds and insects, and to genii presiding over the life-cycle in man and nature (23-25). These are conjured to enter the arcanum magically and present in virtue, if not in substance, to concur in the effect of healing (19).

Another recurrent aim of the hymn is the solumn laud addressed to the herbs and their virtues. It proceeds along the traditional lines of praises offered to the gods in Vedic hymns.

The origin of the herbs is extolled, their ancient and noble lineage is pointed out in flattering terms; they are praised as the first-born of the divine aristocracy of beings, for they all spring from Father Heaven and Mother Earth, the primordial divine

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pair; they have their origin in the primal waters which brought forth the body of the universe and the organisms of all creatures and which maintain them by circulating under various forms through macrocosm and microcosm (2,3).

Moreover, the herbs are reminded of the ancient semi-divine ancestors of the oldest Brāhmana-clans of the Angirases (17, 24), who were the first to discover their virtues and to use them in magic treatment. The herbs are told that they were familiar even to these priestly supermen, these early inventors of magic, who, by their concentrated power of vision, helped the gods to their seats on high in the struggle between divine and titanic powers for world-supremacy.

The many virtues of the herbs are specifically insisted upon (4-7, 9, 10); they are vividly described as irresistible, to make their effectiveness doubly sure (15).

These main themes reappear again and again; with their variations and repetitions, they form the structure of the elaborate score of the charm. The insistence in the refrain is intended to praise and invoke the divine personalities of the herbs; at the same time it is meant to operate along the lines of psycho-somatic treatment as a suggestive stimulus to the patient's will to recover. The varied formulae act as so many comforting, reassuring compulsions on the patient, affording every possible help to his ailing organism.

The plants themselves are blessed, that they may prosper and spread on earth (16), and increase as a blessing to man, by being brought within the human sphere (11, 17). Underlying is the idea that the divine herbs, like most extra-human powers, display a fundamentally ambivalent attitude towards man; that they are indifferent, at best, to man's weal or woe, unless propitiated and made friendly through an established ritual of magic. The herbalist-magician is aware of the fact that the herbs might be reluctant to succor man in his need, or might prove vengeful, having been uprooted and estranged from their proper soil. Their favour has to be courted, not only by extolling their origins and virtues, but by expressly alluding to the hoped for beneficient aspect, which they are urged to disclose. In an apotropaeic euphemism,

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they are styled 'by no means-harming,' 'non-obstructing', and so forth (6); their beneficient nature is thus bespoken and emphasized to ward off any possible ill-will which might manifest itself in a harmful, even poisonous effect. Finally they are besought to protect, in general the health of the inhabitants of the village, men and animals (11).

Other stanzas refer to the actual implements of the treatment; the herbs are besought to bestow their life-giving essence upon the arcanum (12, 17, 25, 27). Possessed of the virtues of the elixir of immortality, or the milk of life, this arcanum is administered as a potion, acting internally to drive consumption out of every part of the patient's body. As an external measure, the patient has tied to himself an amulet of herbs, whose 'tiger-like' strength is praised (14).

Moreover, the magic power of the principal sacred ingredients and implements of the sacrifice to the gods, is invited to join forces with the herbal arcanum as it takes effect (20): the Aśvattha tree, which yields the stick for stirring the sacred and the domestic fires; the holy grass (darbha), which is possessed with exorcising power. The latter serves to cover the altar and the seat of the Fire-god; moreover it is bundled into a brush and used to scrape clean the sacrificial ground, to remove particles of defiling matter which might harbor demonic forces obstructive to the sacrificial procedure. These powerful utensils are invoked to co-operate with the usual oblation to the gods. Soma the nectar, which invigorates the celestials; barley-water and rice-cakes, transubstantiated into divine fare through having been offered to the gods. And the divine materials evidently are to be activated through the unconsumed remainders which are sprinkled upon the amulet. This medicinal ritual is to be inferred from the parallel hymns and the treatment of which they form the oral part.

An indispensable element of the charm intended to secure definite effectiveness, is the solemn and explicit statement that the treatment has already operated according to expectation: 'I have snatched thee away', the doctor addresses the patient in concluding his magic work '...from all sickness...' (28). The result, how-

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ever, is stated in an anticipatory way, as an evocation of the desired effect, at the very outset of the procedure (3): 'they have made depart from thee...thy sinful consumption'.

The all-powerful arcanum of this hymn exhibits a complex pattern of motifs. It looks like the final result of a prolonged process of adding and blending all possible means of treatment together with their proper formulae. To what extent smaller charms, once independent or fragments of earlier hymns were combined to form the incantation as it stands, can only be surmised. Here, a complex mosaic, meant to be encyclopedic, became the classic vehicle of thoughts developed during earlier periods. The intention to create a formulae all-effective through being all-embracing, is evidenced in the present form of the hymn, hallowed by faithful tradition in subsequent ages. It exhibits a wide and detailed knowledge of what forms the subject-matter of materia-medica, and it reveals an intrinsic diffidence and insecurity with regard to the specific effectiveness of the components of this highly praised arcanum.

The foregoing two hymns, one from the Rigveda and the other from the Antharvaveda, give us an insight into the whole procedure about the use of different herbals for treating diseases during Vedic times. There are several other hymns in the Atharvaveda which provide us more information about the specific uses to which different herbals were put to against various diseases. We will have a look at them now.

CLASSIFICATION OF PLANTS

According to their utility, medicinal plants, mentioned in the Atharvaveda, can be classified as follows.[5]

(1) Those that cure different diseases of the body (kāyachikitsā)

(2) Those that cure diseases of the mind (bhutavidyā)

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5. Abridged from Majumdar G.P. (1927) *Vanaspati.* University of Calcutta.

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(3) Those that help in the procreation and protection of children (kaumāra-vidyā).
(4) Those that are used against wounds (śalyavidyā).
(5) Those that are used as antidotes against the bite of snakes etc. (vishavidyā).
(6) Those that are used for securing prosperity and prolongation of life (rasāyana).
(7) Those that are used for virility and erotic success (vajikarāna).
(8) Miscellaneous.

(1) PLANTS FOR DISEASES OF THE BODY

For Leprosy: The plant used is mentioned in the following verses. It is Haridra (Circumalonga).

Night-born art thou, O herb, O dark, black, dusky one;
O colourer, do thou colour this leprous spot and what is pale.

Of the bone-born leprous spot, and of the body born that is in the skin, of that made by the spoiler–by incantation have I made the whole mark disappear.[6]

The Asura-woman first made this remedy for leprous spot, this effacer of the leprous spot; it has made the leprous spot disappear, has made this skin uniform.[7]

For Fevers: The plant used against different fevers is mentioned in the several following verses. It is identified as Costus speciosus or arabicus (Kuśttha).

2. On an eagle-bearing mountain, born from the snowy one; they go to it with riches, having heard of it, for they know the effacer of fever.

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6. AV I. 23.1,4.
7. AV I. 24, 2.

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3. The Aśwattha, the seat of the gods, in the third heaven from here: there the gods won the Kuśttha, the sight of immortality.

8. Born in the north from the snowy mountains, thou are conducted to people in the eastern quarter, there they have shared out the highest names of the Kuśttha.

10. Head-diseases, attack, evil of the eyes, of the body all that may Kuśttha relieve, verily a divine virility.[8]

Thou art born upon the mountains, as the most potent of plants, come hither, O Kuśttha, destroyer of the Takman, to drive out from here the Takman![9]

Thou are born of the gods, thou are Soma's good friend. Be thou propitious to my in-breathing and my out-breathing, and to the eyes of mine!

Superior O Kuśttha, is thy name, 'superior' is the name of thy father. Do thou drive out all disease; and render the Takman devoid of strength!

Pain in the head, affliction in the eye, and ailment of the body, all that shall the Kuśttha heal—a divinely powerful (remedy) forsooth!

(2) PLANTS FOR DISEASES OF THE MIND

The truly-conquering, the curse-repelling, the over-coming, the reverted one—all the herbs have I called together saying—may they save us from this.[10]

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8. AV V. 4.2, 3, 8, 10.
9. AV II. 7.5.
10. AV IV. 17.2, 7.

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Plants identified in the previous hymn are Sahadevi (Sidacordifolia and Rhombifolia) and Apāmmārya (Achyranthes aspera).

By thee do we expel the Apsrases, the Gandharvas; O goat-horned one, drive the demon; make all disappear by thy smell.

Where are the Aśwatthas, the Nyagrodhas, great trees, with crests—thither go away, ye, Apsarases; you have been recognized.

Hither hath come this mighty one of the herbs, of the plants; let the goat-horned arātaki, the sharp-horned, push out.[11]
(Plant mentioned in the above verses is Ajasringe—Odina pinnata.)

In the avakā-eating Gandharvas[12], avaka is Blyxa octandra (a grass-like marsh plant).

The Varana, this divine, forest tree, shall ward off the Yaksha, that has entered this man—that have the gods warded off.[13]
(Plant Varana is Crataiva roxburghii.)

(3) PLANTS FOR PROCREATION OF CHILDREN

The plants of which heaven has been the father, earth the mother, ocean the root—let those herbs of the gods favour thee, in order to acquisition of the goods favour thee, in order to acquisition of a son.[14]

Whoever makes this woman one having a dead child or a miscarriage, him O herb, do thou make disappear, lustful for her, slippery.[15]

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11. AV IV. 37.4, 6.
12. AV IV. 37.8, 9.
13. AV VI. 85.1.
14. AV III. 23.6.
15. AV VIII. 6.9.

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(4) PLANTS FOR WOUNDS

If by a staff, if by an arrow, or if by flame a sore is made, of that thou are relief; relieve thou this man. Out of the excellent Plaksha thou arisest, out of the Aśwattha, the Khadira, the Dhava, the excellent Nyagrodha, the Parna, do thou come to us, O Arundhati.[16]

The plants identified are:

Plaksha : Ficus infectoria
Aśwattha : Ficus religiosa
Khadira : Acacia catechu
Dhava : Anogeissus latifolia
Nyagrodha : Ficus bengalensis
Parna : Butea frondosa
Arundhati : (A climber, Silāci by name)

A preparation of these plants was perhaps applied locally over the injured area.

The berry, remedy for what is bruised, remedy for what is pierced—that did the gods prepare; that is sufficient for life.[17] (The plant is Pippali—Piper longum).

(5) PLANTS AS ANTIDOTES

From the cross-lined (snake), from the black snake, from the adder (what is) gathered—that poison of the heron-jointed one hath this plant made to disappear.[18]
(The plant is Madhuka—Bassia latifolia).

(6) PLANTS FOR PROSPERITY

Indra put thee (Aparajita) on his arm, in order to lay low the Asuras; smite the dispute of (my) counter-disputant: make

16. AV V. 5.4.5.
17. AV VI. 109.1.
18. AV VIII. 56.1.

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them sapless O herb.[19]
(Aparajita is Clitoria ternata.)

Indra consumed the patha, in order to lay low the Asuras....[20]
(Patha is Clypea hernandifolia.)

The Parna, Soma's formidable power, hath come, given by Indra, governed by Varuna, may I, shining greatly, wear it in order to lengthen life for a hundred autumns.[21]
(Parna is Butea frondosa.)

As thou, O Aśwattha didst break out the Khadira within the great sea, so do thou break out all those whom I hate and who hate me.[22]
(Aswattha is Ficus religiosa and Khadira is Acacia catechu.)

Thou are the highest of herbs, Taliśa, of thee the trees are subjects; let him be our subject who assails us.[23]
(Taliśa is Flacourtia cataphracta.)

Me with a portion of Śimśapa, together with Indra as ally, I make myself portioned; let the niggards run away.[24]
(Śimśapa is Dalbergia sisu.)

(7) PLANTS FOR VIRILITY

About thee with an encompassing sugarcane have I gone, in order to absence of mutual hatred; that thou mayest be one loving one, that thou mayest be one not going away from me.[25]

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19. AV II. 27.3.
20. AV II. 27.4.
21. AV III. 5.4.
22. AV III. 6.3.
23. AV VI. 15.1.
24. AV VI. 129.1.
25. AV I. 34.5.

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The plant is Madhuka (Bassia latifolia) or Yaśthimadhu (Glycyrrhiza glabra.)

I dig this herb, of plants the strongest, with which one drives off her rival; with which one wins completely her husband.[26]
(The plant is Pāthā or Vānaparni—Clypea hernandifolia.)

Of the horse, of the mule, of the he-goat and of the ram, also of the bull what vigours there are—them do thou put in him, O Self-controller.[27]
(The plant is Kapitthaka—Feronia elephantum.)

As the black snake spreads himself at pleasure, making wondrous forms, by the Asura's magic, so let this Arka suddenly make thy member altogether correspondent, limb with limbs.[28]
(Arka is Calotropis gigantea.)

Wherewith they invigorate one who is lean, wherewith they incite one who is ill-with, that, O Brāhmanaspati, make thou his member taut like a bow.[29]
(With amulet of Arka wood).

A conciliator, a love-awakener, do thou, O brown, beauteous one: push together both you woman and me; make our heart the same.[30]
(The plant is Andropogon aciculatus.)

(8) MISCELLANEOUS

To grow more hair:

O thou of great leaves blessed one, rain increased, rigeteous! as

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26. AV III. 18.1.
27. AV IV. 4.8.
28. AV IV. 72.1.
29. AV VI. 101.2.
30. AV VI. 139.3.

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a mother to her sons, be thou gracious to the hair, O Sāmi.[31]
(The plants are Prosopis spicigera and Mimosa suma)

Fix thou the old ones, generate those unborn, make longer those born

What hair of thine falls down, and what one is hewn off with its root, upon it I now pour with the all-healing plant.

Fix thou the root, stretch the end, make the middle stretch out, O herb, let the black hairs grow out of thy head like reeds.[32]

SOMA PLANT AND ITS PREPARATIONS

I am sure, everybody interested in the Vedic medicine would like to know something about Soma, the exhilarating, intoxicating drink offered to gods and men, at the time of Vedic sacrifices—especially the Soma sacrifice. Let us see what is Soma, the amrita, the celestial drink.

It is an extract of the stalk of the Soma plant[33] which is said to have been brought to earth by the eagle from the heavens.[34] The plant is described to 'dwell' in mountains and name of the mount Mujavat is specifically mentioned in this regard.[35]

Colour of the plant, as also of the juice extracted from it, is said to be sort of brown or brownish green.[36] Extraction of the juice from the plant was done by crushing the stalk with a stone[37] or in a mortar and pestle.[38] The juice was strained by letting it ooze through sheep's wool.[39] Thus filtered, it was mixed with

31. AV VI. 30.3.
32. AV VI. 136, 2, 3; 137.3.
33. RV IX. 67.28.
34. RV V. 45, 9 IX. 68.6 X. 114.5.
35. RV I. 28.1-4.
36. RV I. 92.1.
37. RV IX. 107.10.
38. RV I. 28.1-4.
39. RV IX. 69.9.

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water, milk and honey and offered to gods. It was also mixed with barley or even with ghee.[40] Soma juice from the plant was extracted at different times of the day for offering it to different gods.

Its reaction on the body, after taking it, is described as 'like roar of a bull'[41]. It acts swiftly.[42] It is exhilarating and invigorating. It stimulates speech also.[43] The worshippers, after taking it, exclaim, 'we have drunk Soma, we have become immortal, we have entered into light, we have known the gods'[44]. After taking it, Indra slew all foes and no one could resist him in battle.[45]

Soma juice had medicinal powers also. It is said to have healed the sick, made blind see and lame to walk.[46] It bestowed long life[47] and increased fertility.[48] Soma is the lord of all plants.[49]

Soma plant has not yet been recognized botanically. Different conjectures have however, been made by many scholars. It probably belongs to Ephedra family and may be either Ephedra pachyclade or Ephedra distachya.

AGRICULTURE

The following hymn of the Rigveda pictures for us an agricultural-cum-pastoral community of the Vedic period. It also speaks of their needs and aspirations and provides us an insight into the techniques of agriculture employed by them.

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40. RV IX. 82.2.
41. RV IX. 16; VI. 69; IV. 71.7.9.
42. RV I. 4.7.
43. RV VI. 47.3; IX. 8.4 4; IX. 95.5; IX. 97.52.
44. RV VIII. 48.3.
45. RV IX. 1.10.
46. RV VIII. 68.2 X 25.11.
47. RV I. 91.6; VIII. 48.4 7.
48. RV IX. 80.4.49.
49. RV IX. 114.2.
50. RV IV. 12.57.

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2. Lord of the field, bestow upon us sweet, abundant (water), as the milch cow (yields her) milk dropping like honey, bland as butter: may the lord of water make us happy.

3. May the herbs (of the field) be sweet for us, may the heavens, the waters, the firmament, be kind to us; may the lord of the field be gracious to us: let us, undeterred (by foes), have recourse to him.

4. May the oxen (draw) happily, the men (labour) happily, the plough furrow happily; may the traces bind happily; wield the good happily.

5. Suna and Śira be pleased by this our praise and consequently sprinkle this (earth) with the water which you have created in heaven.

6. Auspicious sitā (furrow) be present, we glorify thee: that thou mayest be propitious to us, that thou may yield us abundant fruit.

7. May Indra take hold of sitā (furrow), may Pushan guide her; may she, well stored with water, yield it as milk, year after year.

8. May the plough-shares break up our land happily; may the plough-man go happily with the oxen; may Parjanya (water the earth), with sweet showers happily: grant, suna and śira, prosperity to us.

The Rigvedic Aryans used cattle and horses for pulling the plough, and irrigated their fields by getting water from the wells, as is indicated by the following hymn.[51]

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51. AV X. 150.

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3. Harness the ploughs, fit on the yokes, now that the womb of earth is ready, sow the seed therein, and through our praise may there be abundant food; may (the grain) fall ripe towards the sickle.

5. Set-up the cattle-troughs, bind the straps to it, let us pour out (the water of) the well, which is full of water, fit to be poured out, and not easily exhausted.

7. Satisfy the horses, accomplish the good work (of ploughing), equip a car laden with good fortune, pour out (the water of) the well, having wooden cattle-trough, having a stone rim, having a receptacle like armour, fit for the drinking of men.

11. The beast of burden pressed within the two wagon-poles, moves as if on the womb of sacrifice having two wives. Place the chariot in the wood, without digging store up the juice.

STRUCTURE OF THE PLANTS

A rudimentary description of the different medicinal plants is given in the following verses of the Atharvaveda.

The spreading, the bushy, the one-spathed, the extending herb do I address, those rich in shoots, jointed, that have spreading branches; I call for thee the plants that belong to all the gods, formidable giving life to man.

Rich in sweet the root, rich in sweets the tip of them, rich in sweets was the middle of the plants, rich in sweets the leaf, rich in sweets the flowers of them all.

Rich in flowers, rich in shoots, rich in fruits, also those lacking fruits—like joint mothers etc.[52]

52. AV VIII. 7.4, 12, 27.

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Vishnu Purāna gives the following account of the different parts of the paddy plant.

'O the greatest of sages, just as there are embryo (ankur), root (mūla), stem (nāla), leaf (pātra), flower (pushpa), milky sap (kshira), husks (glumes-tusha), seed-vessel (kosha, vija kosha), seed (tandula, rice) and endosperm in the seeds (tandula rice) and endosperm in the seeds (kāna) in the paddy, and they become manifest only under suitable conditions such as soil, water etc...'[53]

In Brihadāranyak Upanishad the body of the plant is compared as follows with the body of a human being, part by part.

The body of the plant is exactly like the body of man; the hairs of man corresponding to the leaves of plants and his skin corresponding to the dry exterior bark of the plants. The flesh of the human body answers to the śakara (soft tissue next to the skin) of plants: his nerves standing for the kināta (fibrous tissue in śakara as in the jute etc.) of plants, both being equally strong. Just as the bones of man lie behind his flesh, so also wood darū, lies behind the śakara (and occupying the centre) of plant and the marrow (pith) is alike in both.[54]

SENSE-PERCEPTION IN PLANTS

In Mahābharāta, in a certain reference, Bhrigu gives the following reply to Bharadwaj about the sense of consciousness in plants:

'How can we doubt the existence of their gift of touch, seeing their leaves, bark, fruit and flowers wither under the influence of heat? We must infer the gift of hearing in them, seeing that their fruits and flowers dry up under the influence of wind, fire and sound of thunder. Eyeless creatures can never go their way of themselves, and as creepers approach and wind round the trees and move at will, we must admit the existence of sight in them. And as they can be healed for their diseases by the application of odour both pleasant and unpleasant and also by frankincense

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53. Vishnu Purāna VII. 37-39.
54. BAU III. .9.

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of various types, it is sure that they possess the power of sense. The organ of taste in them must be inferred from the fact that they are capable of drinking water through the root. As we suck up water through a lotus stalk applied to the mouth, so do plants, with the help of air, drink up water through their roots. Thus as they are found to be sensitive to pleasure and pain and as they are seen to undergo regeneration after mutilation, we must admit the existence of life in them. Fire (energy) and air help in the assimilation of the water that unmoving beings like trees take up (from the soil) through the roots'.[55]

PLANTS PRECEDED MAN

Regarding the question which appeared first on earth, the man or the plants, the following story in Ramāyāna tells the answer in decisive terms:

'Once an owl and a vulture quarelled over the possession of a nest in a certain tree, each laying an equally emphatic claim to its ownership. Unable to settle the dispute themselves, they preferred an appeal to Rāma. On being asked how long they had been there, the vulture replied that he had been there since man began to inhabit the earth. The owl replied that he had been there since the earth became decorated with plants. In consultation with his ministers, Rāma decided in favour of the owl, on the score of the prior appearance of plant on earth.[56]

55. M B. Shantiparva 184.
56. Ramāyāna, Uttarakanda 72.

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14

Scientific Methodology

Research and investigation in any subject, be it science, arts, philosophy or theology, requires certain methods to be followed. Ultimate analysis of these methods shows that there are certain basic principles, which are essentially the same for every subject of study. These basic principles were sought, investigated and formulated in the form of Nyāya sutras by an ancient Indian philosopher-scientist called Gotama or Akśapāda. Through them he aimed at understanding and knowing the Creator and His creation, so that he could attain liberation of the soul—the highest goal that an earthling could aspire for.

These principles are part of the literature which is generally considered as religious or philosophical. Hence it did not attract the attention of many scholars. But those who have studied them carefully, are coming to the conclusion that these principles have been evolved with lot of care and understanding, and the results obtained by their application lead to valid and wholesome knowledge. These principles have stood the test of time and though ancient yet compare very well with many of the modern methods.

AKŚAPĀDA GOTAMA

A sage Akśapāda is described in Vāyu purāna, as a disciple of a Brāhmana called Soma Śarma who was said to be Śiva incarnate and who was well-known for the practice of austerities at a shrine in Prabhāsa during the time of Jatukārna Vyāsa. In this purāna alongwith Akśapāda's name is that of Kanāda also, and it appears that this sage Akśapāda is no other than Gotama who

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founded the Nyāya sūtras and the system of philosophy of the same name. Akśapāda literally means, 'the one having eyes in the feet', and according to a legend, it is said that Gotama was usually so deeply absorbed in philosophical contemplation that one day while walking, he fell into a well and was rescued from there with lot of difficulty. Seeing his plight, God mercifully provided him with a second pair of eyes in his feet and thus protected him from further mishaps.

Local tradition of Mithila, modern Darbhanga in North Behar, ascribes the foundation of Nyāya philosophy to a Gotama, husband of Ahalyā. It even points out the place of his birth, a village called Gotamasthāna, where a fair is held every year on the ninth day of the lunar month of Chaitra (March-April). This village is situated 28 miles north-east of Darbhanga and has a high mound in it, supposed to be the site of the hermitage of the sage Gotama. At the base of this mound is a water-spring called Gotama kūnda, whose water is said to taste like milk, from this spring arises a stream called Kśirodadhi or Khirori (literally meaning, a sea of milk).

The family tree of Akśapāda Gotama can be traced back even to Rigvedic times. Gotama, son of Rahugāna, is said to be the founder of the Gotama family.

The conflict in the identity of Gotama and the places associated with his name, has tentatively been resolved by admitting that he was born at Mithila on the river Kśirodadhi (as stated by the local tradition of Mithila), he lived for some time in the village now called Godna at the confluence of the Ganges and Sarayu (as mentioned in Adhyātina Rāmayāna), and he contemplated and retired later to a place called Prabhāsa, the well-known sacred spot in Kathiawar on the sea-coast.[1]

Akśapāda Gotama said to be a contemporary of Kanāda and the Buddha, lived during the sixth century B.C.

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1. As mentioned in the introduction of the Nyāya sūtras of Gotama, in the series, *The Sacred Books of the Hindus* Vol. VIII. Translated into English by S. C. Vidyabhusana, published at Allahabad, 1930.

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NYĀYA SUTRAS

The Nyāya sutras (nyāya means analysis) which contain the system of philosophy composed by Gotama, in their present form, seem to belong to a period not earlier than second century A.D. That however, does not militate against their original antiquity or the genuineness of the essential theme expressed in them.

Nyāya sutras text is divided into five books and each one of them contains two chapters. Whether the whole of this text is the work of Akśapāda Gotama himself, there is no unanimous opinion about it. During later times, around 450 A.D., Vatsyāyana wrote a commentary on the Sutras and modified and harmonized the different conflicting views that had developed about the basic texts of the Sutras by that time.

The Sutras begin by enunciating the significance of knowing the contents of the text. It says:[2]

'Supreme felicity is attained by the knowledge about the true nature of the sixteen categories *viz.*, means of right knowledge (pramāna), object of right knowledge (prameya), doubt (samsayā), purpose (prayojāna), familiar instance (driśtānta), established tenet (siddhānta), members (avayāva), confutation (tarka), ascertainment (nirnāy), discussion (vāda), wrangling (jalpa), cavil (vitanda), fallacy (hetvabhaśā), quibble (chhāla), futility (jāti) and occasion for rebuke (nigrasthāna)'.

'Pain, birth, activity, faults and misapprehension, on the successive annihilation of these in the reverse order, there follows release.'

TO ESTABLISH A 'FACT'

According to Nyāya, there are four methods of establishing the true identity of a fact, a phenomenon or an object. They are: perception (prātyāksha), inference (anumāna), comparison (upamāna) and testimony (aptavākya).

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2. Nyāya sutras. Book I. 1.1, 2.

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(1) PERCEPTION

It is the recognition and knowledge of the objects, produced by their contact with various sense organs such as of sight, hearing, touch, taste, smell and mind. Though it includes observation, it certainly embraces much more than that alone.

Types of Perception: If there is a direct sense-object contact, it leads to what is called Ordinary Perception. This is of two types: the External and the Internal, according to whether the contact of the object is with external senses or with the internal one *i.e.*, the mind.

When the object or a phenomenon is such that it is not ordinarily present to senses or an appropriate sense or is recognised through an unusual medium, its recognition occurs through what is called as Extra-ordinary Perception. This is of three types: when we say all men are mortal, we perceive the universal truth in a class; when we say that ice looks cold, we are perceiving this through a sense which is ordinarily not capable of perceiving it; and last is the intuitive perception of the objects, past, future or hidden by one who possesses some supernatural power.

(2) INFERENCE

It is the knowledge of the objects through the apprehension of some mark which is invariably related to the inferred object. This is best illustrated by the oft-quoted though out-moded example: 'The hill is fiery, because it smokes and whatever smokes is fiery'. The order of events that take place when we infer this is: first the apprehension of the smoke in the hill, second the recollection of the universal relation between smoke and the fire and third the recognition of the fire in the hill.

For inference to be valid, it must fulfil certain essential requirements. Firstly, there should be a relation of agreement in presence (anvāya) between two things, *i.e.* in all cases where one is present, the other should also be present *e.g.*, 'wherever there is

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smoke there is fire'. Secondly, there should also be uniform agreement in absence between them (vyātireka) *e.g.*, 'wherever there is no smoke there is no fire'. Thirdly, no contradictory instance should be observed where one of them is present without the other (vyabhicaragrāha).

Besides the above three fundamental requirements, there are others which are as essential, namely, elimination of all the conditions on which this relation may be possibly depending (upadinirāsa), and also when a generalisation is made from a particular instance, it must be ultimately based on the knowledge of the essential nature of the things.

Observation of agreement in presence and absence, with non-observation of the contrary between two phenomena, though generally leads to establishment of the invarible concomitance (vyapti) between the mark and the character inferred *e.g.*, smoke and fire, yet this may not be enough in every case, as is witnessed in the following example. Suppose daily as a man comes from office, he puts on the radio and a child living next door hears a song in a female voice daily at that time. A hundred times, the child observes that when the man comes home he hears the song and also a hundred times he observes that he does not hear it when the man is not there. If the child is not aware of the radio and does not know any other thing in the matter, he might infer that the man sings in a female voice. Similar inferences, I am afraid, are sometimes come across in scientific work also. But this is not correct.

So it is seen that agreement in absence or presence, unbroken and uniform though it may be, is not enough to lead to a valid inference. Relevant hidden determining conditions (upādhi) and accompanying circumstances have to be taken successively, investigated and eliminated by repeated experiments and observations, to establish an invariable concomitance (vyapti) between the mark and the character inferred, and only then can be obtained the knowledge which is valid and correct. All these conditions and even much more has been adequately taken care of in the Nyāya sutras of Gotama.

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(3) COMPARISON

Comparison (upamāna) is the knowledge of the objects or phenomena obtained by the establishment of a relation between a name and objects so named or between a word and its denotation. This is illustrated by the following example. A man is told that an animal with such and such a description is a cow. When he sees an animal for the first time with particulars which fit in with the description, he concludes, by comparison, that what he is seeing is a cow.

Comparison as a distinct source of knowledge, however, has not been recognized by other systems.

(4) TESTIMONY

The fourth method of establishing the identity of an object is testimony (aptavākya) *i.e.*, the knowledge of the perceived and unperceived objects derived from the statement of authoritative sources *viz.*, scriptures such as the Vedas or the sayings of the saints and the sages. This source of knowledge has been much criticized by Western scholars with the plea that utter acceptance of the authority of the Vedas, has been a great limiting factor and hindrance to the development of proper reasoning. But, perhaps, they do not know as to how many interpretations, according to the individual way of thinking, have been put forward and accepted by various scholars and people, to whatever is written in the Vedas. These interpretations have been sometimes poles apart, but that has not in any way infringed upon the profoundest veneration in which the Vedas are held.

It is important to note that for Indians their theories and philosophies were not of academic interest only. They actually lived those ideologies and also applied them in their practical sciences. Theory, practice and treatment of the Āyurvedic medicine is extensively and elaborately based on Nyāya and other systems of Indian philosophies. These so-called philosophical systems are, in fact, as basic to the understanding of Āyurveda as certain

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non-clinical subjects are to the understanding of Western medicine or other applied sciences.

NYĀYA RELATED TO VAIŚESHIKA

Nyāya system originated during the rationalistic tendency of the Upanishadic period and as in the beginning, it did not base its doctrines on the authority of the Vedas, it did not find favour with the Brāhmanas. Later on, however, instead of relying completely on reason alone, it did attach due weight to the Vedas and thus a reconciliation occurred and this led to exchange of ideas between Nyāya, Vaiśeshika, Yoga, Mimansa, Sāmkhya systems etc.

Vaiśeshika and the Nyāya systems have all along been treated as sister systems (samāna-tāntra), with a common rationalistic stress and realistic background, inspite of certain terminological differences. The Nyāya category of prāmeya, the things to be known, covers the things categorized by the Vaiśeshika, and the latter also discusses perception, inference and verbal testimony in its text. It is not surprising then to find the two schools becoming, to all intents and purposes, one around the eleventh century A.D. The most highly developed work of this syncretic school was produced in north India between the thirteenth and seventeenth centuries by a group of philosophers whose greatest exponent was Gangeśa. This new school is often called Navya-Naiyāyikas, the new Naiyāyikas; the newness of the school lay in its emphasis on greater precision.

LOGIC IN THE WEST

Aristotle (384-83 to 322 B.C.) felt that correct thinking like correct speaking needed an elucidative and regulative aid. He thus founded a distinct branch of investigation which came to be designated as Logic, the name Logic being etymologically connected with the word, 'logos', which denotes both thought and word or discourse. Methods and observations in this regard, Aristotle set forth in his work called Organon.

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Aristotle's methodology was based on the principal of observation by the senses. According to him, our minds quite spontaneously and constantly, generalize from particular cases. Concepts are therefore not latent in our minds but are formed from experience by discrimination, perception and memory. Observed facts are stored, objects are classified, fleeting images are stabilized and the facts consolidated, because the human intellect has the ability to derive concepts from sensations. Aristotle believed that we start with sensible objects and proceed little by little, by means of classification and generalization to truly scientific concepts.

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15
Technology

Vedic literature gives us some information about the technological aspects of that era. This information is, however, deduced in an indirect way. Different Samhitās and Brāhmanas mention the names of many professions or professional people in different contexts. Naturally then, these professions indicate the technical skills of the people and of the times.

Yajurveda, in its third chapter, lists names of the following professions.

Forest-ranger
Wood-cutter
Charioteer
Plough-maker
Bow and arrow-maker
Maker of things out of bamboo.

Iron-smelter
Sword-maker

Gold-smith
Jeweller

Potter
Brick-maker
Fire-maker

Rope-maker
Spinner

Embroidery worker (she)
Dyer
Washer-woman
Leather-tanner
Leather-worker

Physician
Astrologer
Priest
Money-keeper
Grocer
Drum beater
Vena player
Flute player
Musician
Dancer

Gambler
Wine-maker (surākar)

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Weaver
Plough-man
Gardener
Seed-grower

Horse-man
Guards-man
Gate-man
Watch-man

Fish-catcher
Fish-seller
Tortoise-catcher
Hunter
Elephant-catcher
Horse-catcher
Shepherd

Besides the names of different professions, names of certain things, articles or implements are also given in different Vedic texts. These names are also indicative of the technical skills of the times. Such names, alongwith the texts wherein they are mentioned, are given below:

Name of the Article	*Reference*
Hook	RV VIII. 17.10
Spade	YV XI. 10; S.B. VI. 3.1.30
Knife	RV X. 86.18
Razor	AV VI. 68.1
Mortar and Pestle	S.B. 1.1.1.22; AV IX. 6
Loom-warp	RV X. 71.9
Shuttle for weaving	RV X. 130.2; YV XIX. 83
Wool and thread	S.B. XII. 7.2.11
Potter's wheel	S.B. XI. 8.1.1
Chariot	RV I. 30.18
Cart	RV III. 33.9; S.B. 1.1.2.5
Wheel	RV 1.30.19
Spokes	RV X. 78.4
Wooden plough	S.B. VII. 2.2, 2-3
Winnowing basket	YV 1.14
A measuring cord	RV VIII. 25.18
Netting	S.B. VI. 7.1.18, 20

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Name of the Article	*Reference*
Chair, stool	S.B. V. 4.4.1
Mat	S.B. XIII. 2.2.19
Cushion	S.B. XIII. 4.3.1
Cushion-cover	AV IX. 6.10
Fire-pan	S.B. 1.1.1.22
Pitcher	S.B. V. 5.4.27
Wooden-tub	YV XVIII, 21; S.B. III. 6.3.10
Drum	YV XXIX. 57; S.B. V. 1.5.6
Filtering-cloth	S.B. IV. 3.2.11
Black antelope's skin	S.B. 1.1.4.1.

Besides the above, different other household utensils and articles, have been mentioned many times in different places. These are cups, ladles, spoons, pots storage jars, mill-stone, fire-producing stone, clarified butter etc.

For preparing Soma juice different procedures undertaken by Vedic Aryans were, grinding, pounding, macerating with water, squeezing, filtering, collecting in pots etc.

The above names of the professions and the articles, picture for us the agricultural-cum-pastoral people who lived in more or less self-sufficient small village communities. Most of their needs were met with within the community itself.

While we do not know enough about the importance and the social standing of different occupations and professions, we do know that chariot-makers were held in high esteem and were considered as persons who possessed great mental capabilities. Different Rigvedic hymns praise their skill.[1]

In the Mahābharāta, there is mention of Matsyayantra, a contrivance which had a revolving wheel with an attached fish, which Arjuna shot, not by looking at it directly but by looking at its shadow in the water. It is plausible that this wheel-like contrivance revolved on a pivot inserted in its central hole.

In Harivamsa, a supplement to the Mahābharāta, a stone-throwing contrivance (Asma-yantra) is mentioned in connection

1. RV 1.130.6; V.2. 11; 29.15, 73.10; X. 39.14.

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with a battle.[2]

Ramāyāna mentions of a Yantra-dhvāja, a flag raised or lower with the help of ropes running probably on pulleys. The full particulars of the erection and dismantling of the Indra dhvāja are set forth by Bhoja in a chapter of over 200 verses, exclusively devoted on it in his Samarangana sutradhara. The central pole, the pedestal, the painted flag itself, the subsidiary fittings, the dolls to be hung on it, its out-stretched arms, the six ropes attached to it and several yantras fitted to it for raising it and bringing it down, are described.[3]

Ramāyāna also mentions of yantras with which forts were equipped as a defensive measure. Hanumāna reported back to Rāma that the four gates of Lankā were equipped with huge yantras which could throw both the arrows as well as stones,[4] and over the moat were bridges which also carried different battle machines or contrivances.

Though the above references in the epics, about different mechanical contrivances give only a vague description yet even this account is enough to give, at least, a general idea of the contrivances with which things could be pulled up, brought down or thrown at a distance with a force.

COPPER HOARDS

Archaeological exploration of the area around Ganges-Yumana basin has brought to light, from over three dozen different sites in Uttar Pradesh, Madhya Pradesh, Andhra, Behar, West Bengal and Orissa, a distinctive series of hoards of objects, made out of copper and rarely of bronze also. They comprise eight main following types:

(1) Flat axes, usually of stocky sub-rectangular form with splayed edge.

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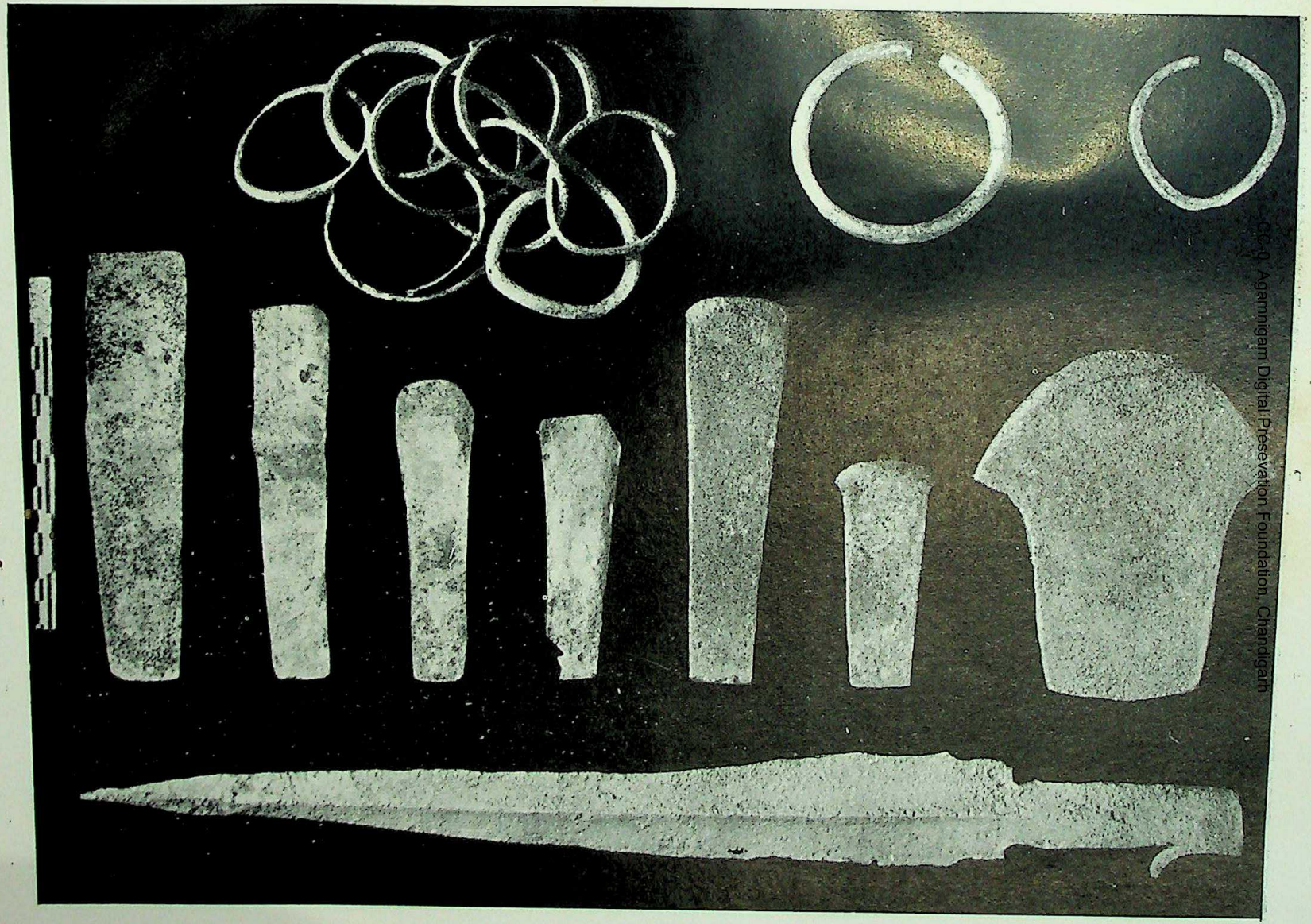
2. Harivamsa II 42.21.
3. Quoted by Raghavan, V., in *Yantras or Mechanical Contrivances in Ancient India.* Ind. Instt. of Cult. Bangalore. 1952.
4. Ramāyāna, Yūddha 312.



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Copper Hoard, Bahadrabad

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(2) Shouldered axes with a clear kink or set-back at the points where the curved edge meets the stem of the implement.

(3) Bar-celts or chisels, up to 2 feet long, consisting of a nearly parallel-sided bar and an expanded chisel-edge in one of the lateral planes, not central as in the axes.

(4) Rings made by bending a rod of circular section until the ends meet.

(5) Harpoon-heads with bilateral barbs and a loop or projection for the attachment of a cord.

(6) Spear-heads (sometimes called swords) with strong mid-rib and often with a projection from the tang for the attachment of a cord.

(7) Swords, usually with the hilt or tang, of one piece with the blade and bifurcated like antennae.

(8) Strange anthropo-morphic objects, upto 18 inches long, which might be taken to represent a human form with straddled legs and incurved arms. Their purpose and whether indeed their anthropo-morphism is intentional, is unknown.

The axes, up to a foot in length and five or six pounds in weight, could be used for wood-cutting. The barbed harpoons must have been used for fishing and even for hunting. The swords which occur on four of the sites, imply a more militant element.

To be precise about the period to which these hoards belong is difficult at present. Anthropo-morphic object discovered at Lothal, an Harappān civilization site, may be placed around the eighteenth or seventeenth century B.C. For the rest, the period surmised is before 1000 B.C., anywhere between 1700-1000 B.C.[5]

These copper hoards could belong to the refugees from the Harappān clvilization of the Indus Valley or to the Aryans who occupied this territory.

For us here, the relevant point is that the use was made of

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5. Wheeler M. (1966) *Civilizations of the Indus Valley and Beyond*, Thames and Hudson, London.

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copper and also of bronze to make such implements between 1700-1000 B.C. in India.

USE OF IRON

Besides the evidence of the Vedic literature which mentions at different places the use of iron by the Aryans, archaeological evidence of the use of iron within the Indian subcontinent first appeared from Taxila (now in West Pakistan, near Rawalpindi), which can be dated around 500 B.C.

Recently, low down in the mound at Atranjikhera, in the Etawa district of Uttar Pradesh, iron objects have been found which can be dated around 1100 or 1000 B.C.[6]

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6. Wheeler M. (1966) *Civilizations of the Indus Valley and Beyond*, Thames and Hudson, London.

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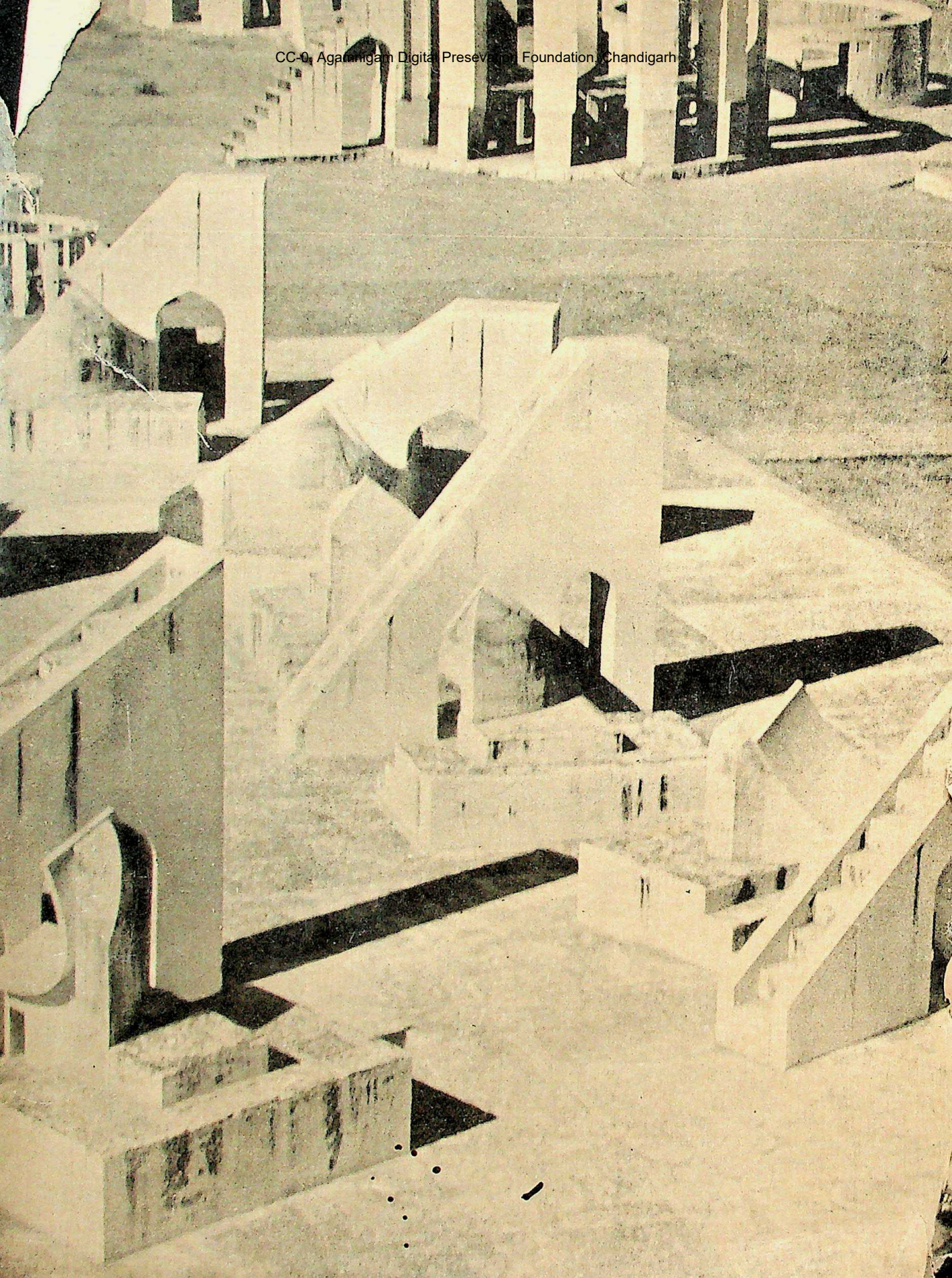
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